



US006772433B1

(12) United States Patent
LaJoie et al.(10) Patent No.: US 6,772,433 B1
(45) Date of Patent: Aug. 3, 2004(54) INTERACTIVE PROGRAM GUIDE FOR
DESIGNATING INFORMATION ON AN
INTERACTIVE PROGRAM GUIDE DISPLAY

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: 09/185,179

(22) Filed: Nov. 3, 1998

Related U.S. Application Data

(63) Continuation of application No. 08/802,833, filed on Feb. 19, 1997, now Pat. No. 5,850,218.

(51) Int. Cl.⁷ H04N 5/445; H04N 7/173; G06F 3/00; G06F 13/00

(52) U.S. Cl. 725/52; 725/33; 725/58; 725/104; 345/767; 345/786

(58) Field of Search 725/44, 52, 53, 725/38; 345/830, 828, 829, 831, 784, 786

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Primary Examiner—Vivek Srivastava

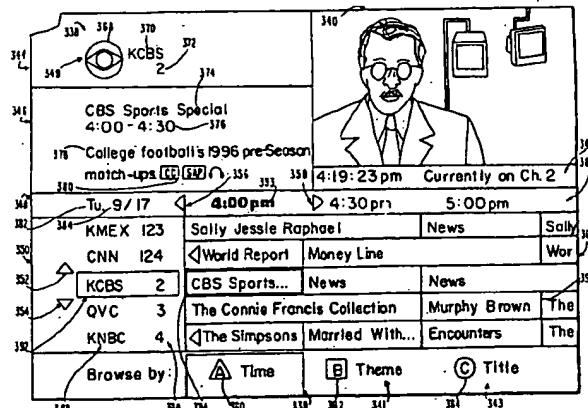
Assistant Examiner—Andrew Y. Koenig

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(57) ABSTRACT

A system and method are provided for providing a full service cable television system. The cable system incorporates a digital and analog transmission architecture capable of delivering a high number of high quality television programs, advanced cable services, and online services to a subscriber's home. The cable system comprises a cable headend, at least one fiber transport, at least one distribution hub, at least one hybrid fiber coax plant, and a plurality of set-top terminals. Programs and services are transmitted to the set-top terminals in both digital and analog formats to maintain downward compatibility with existing systems. The set-top terminal incorporates a central processing unit, a unified memory architecture, a memory management unit, communications circuitry, I/O control circuitry, and audio and video output circuitry. Through these components the set-top terminal provides advanced cable services such as a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On-Demand and Video-On-Demand programming, and advanced configuration controls. The set-top terminal also provides online services such as World Wide Web browsing, Internet E-Mail, and Home Shopping.

20 Claims, 35 Drawing Sheets



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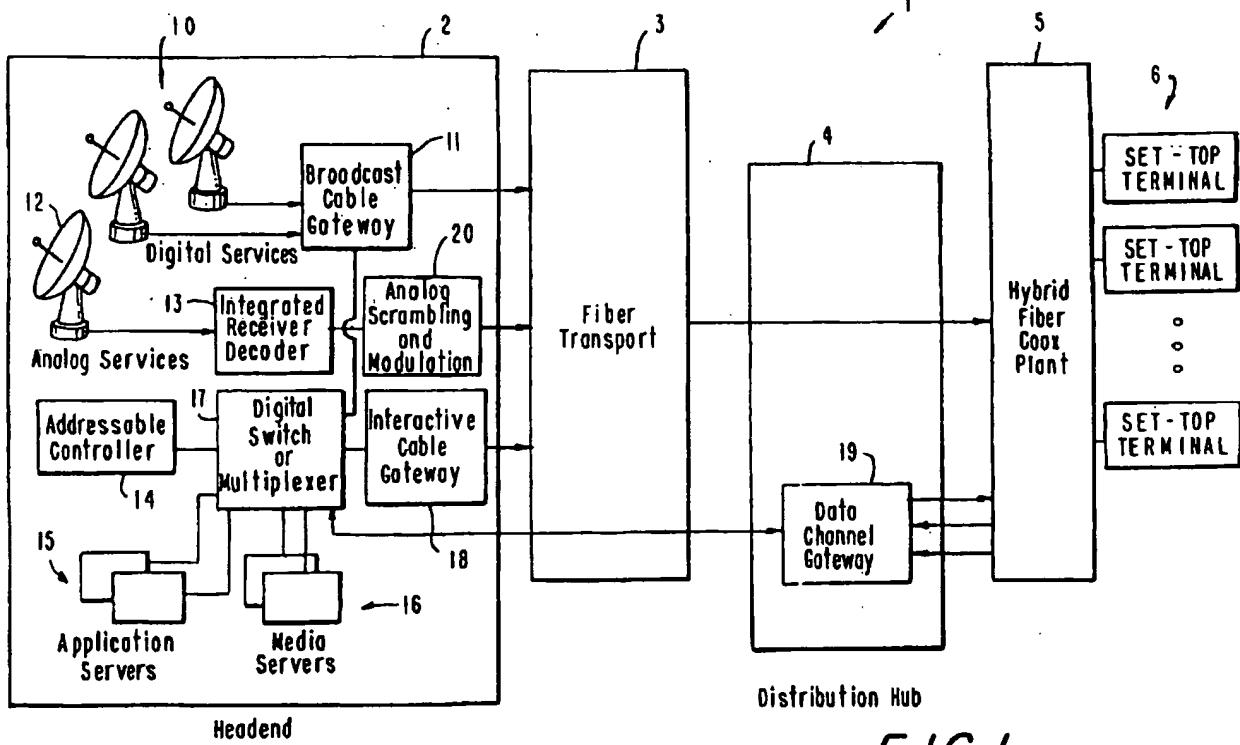


FIG. 1

FIG. 2

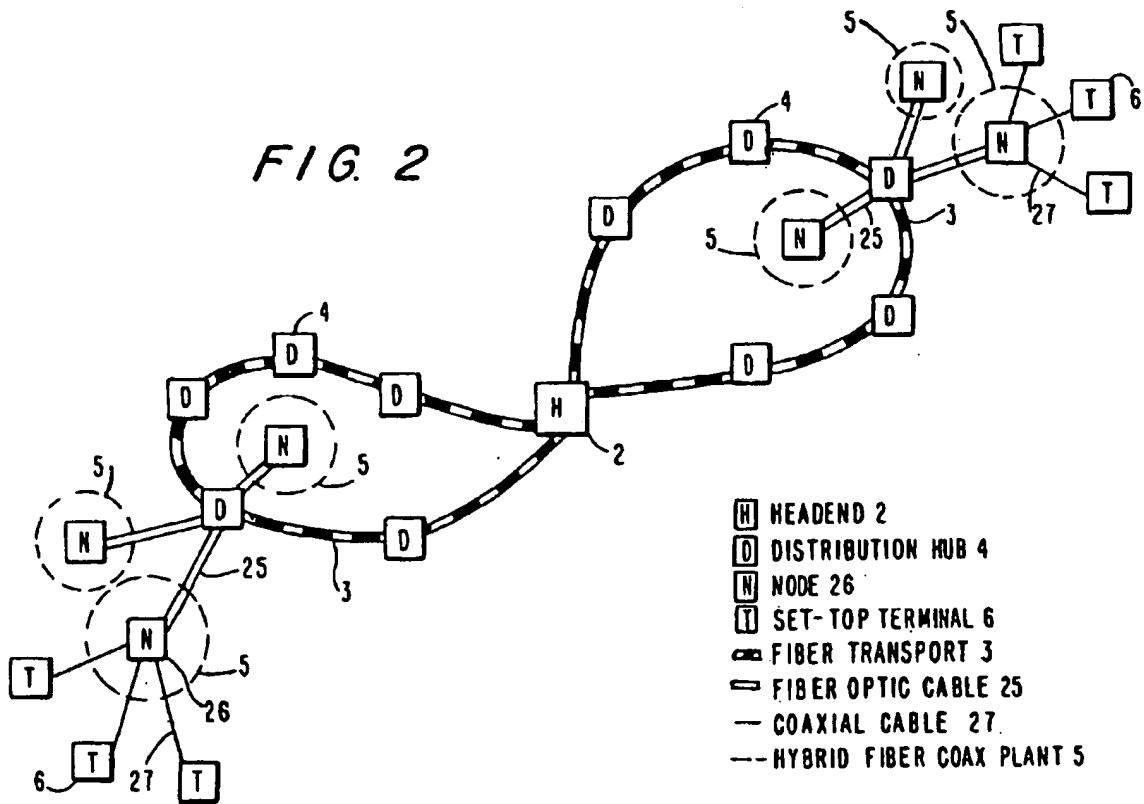


FIG. 3

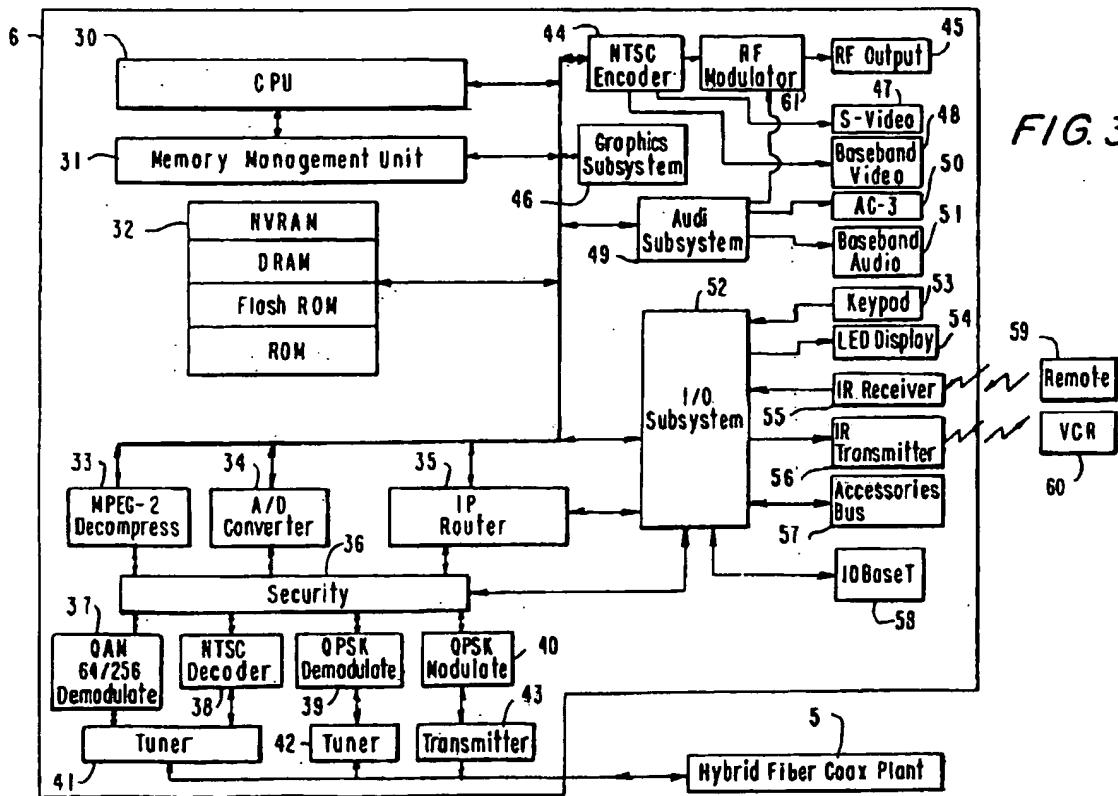
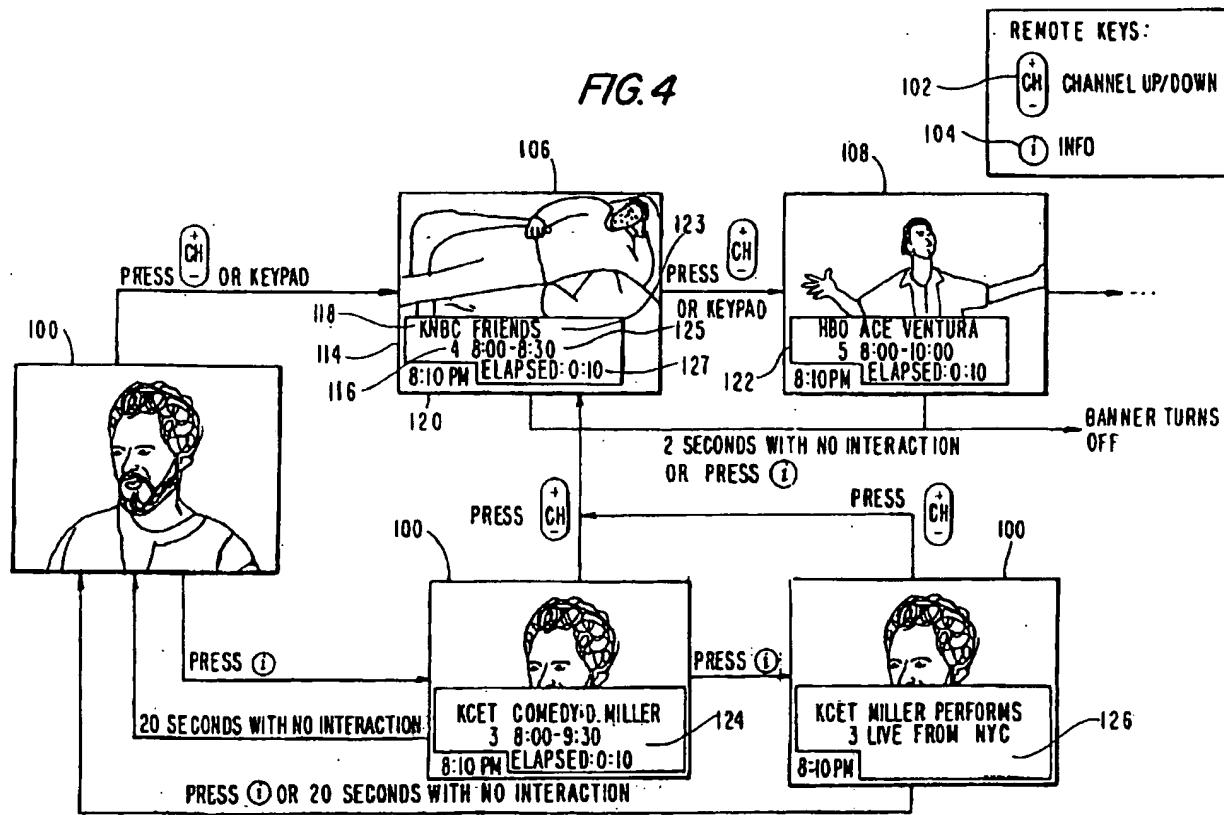


FIG. 4



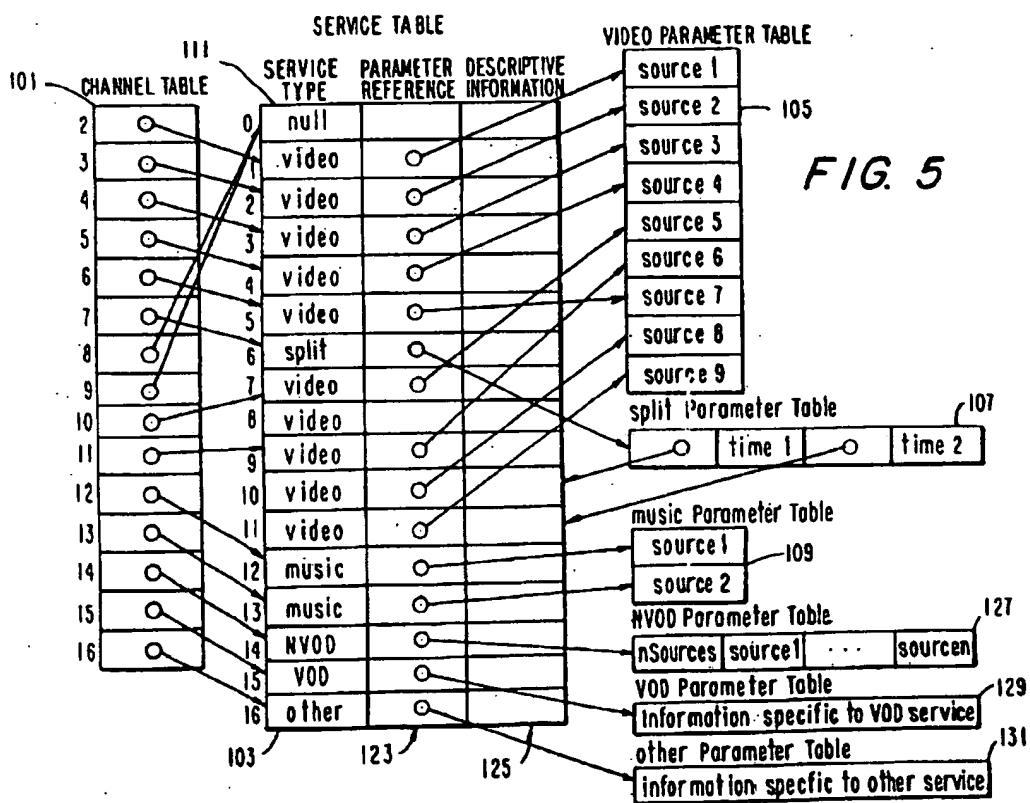


FIG. 6

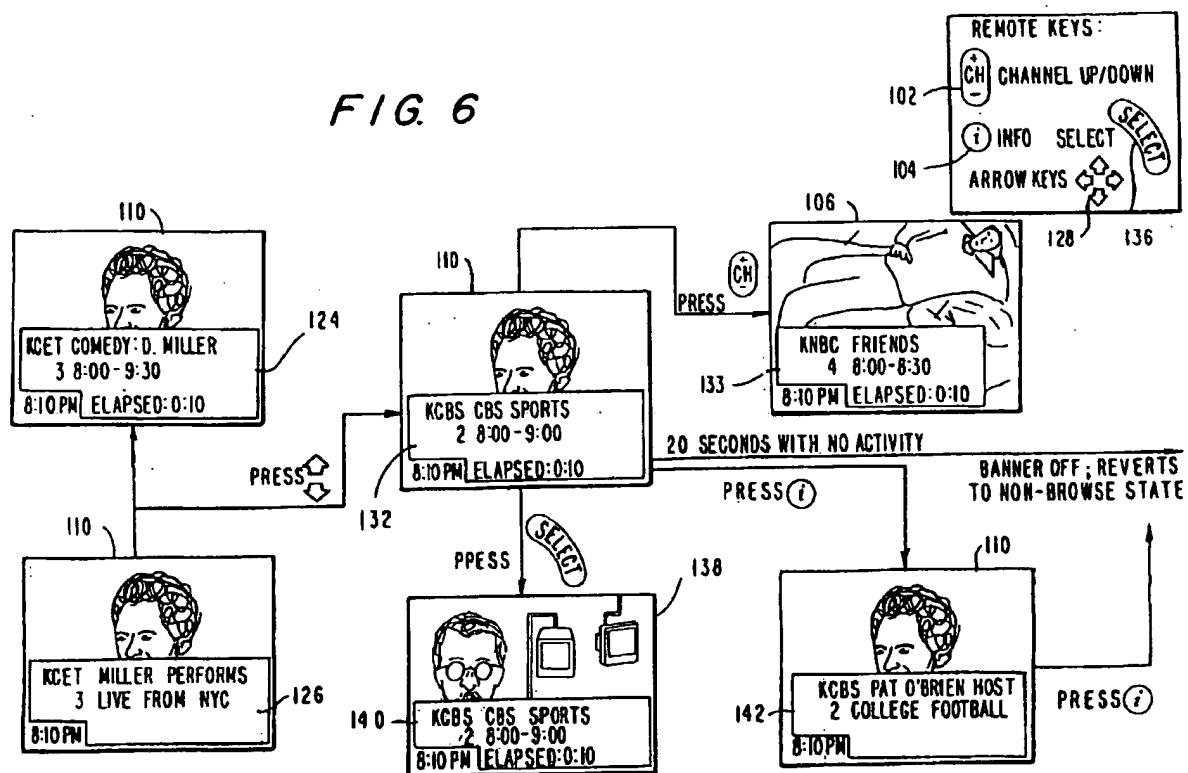


FIG. 7

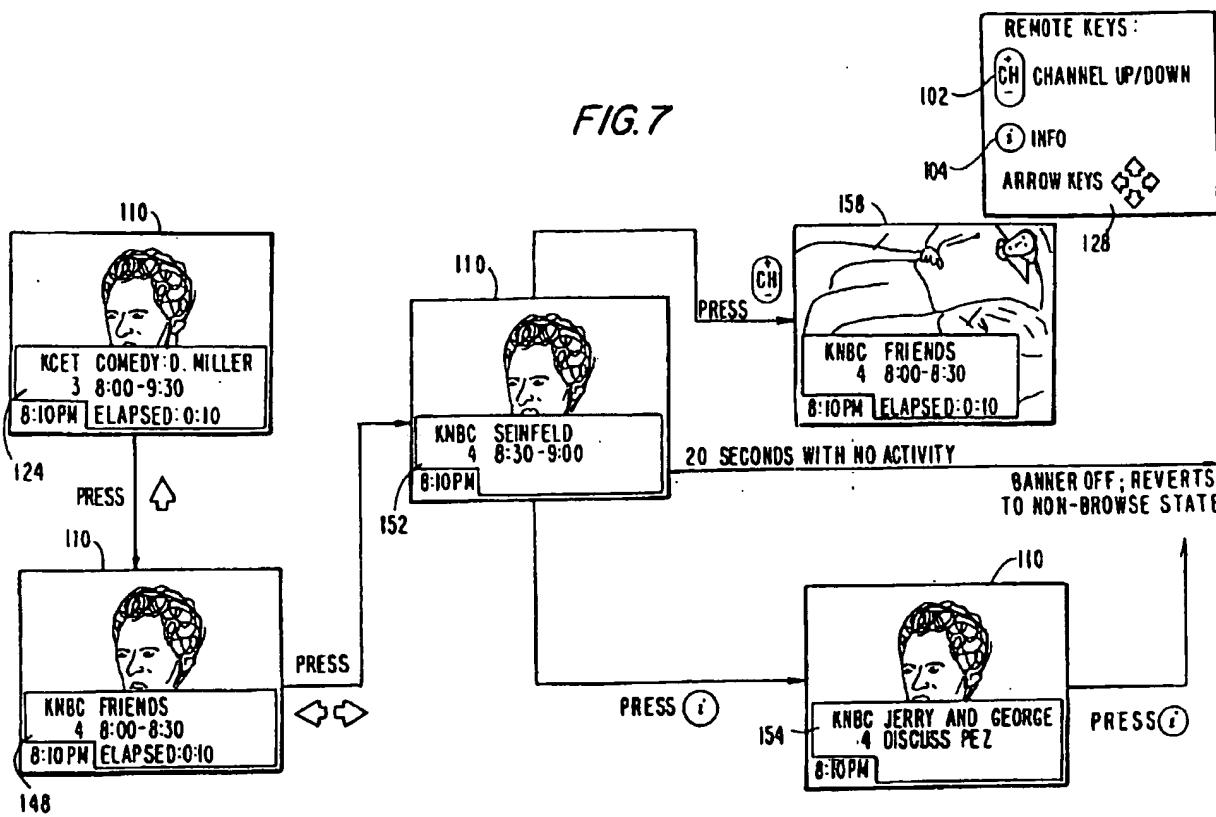
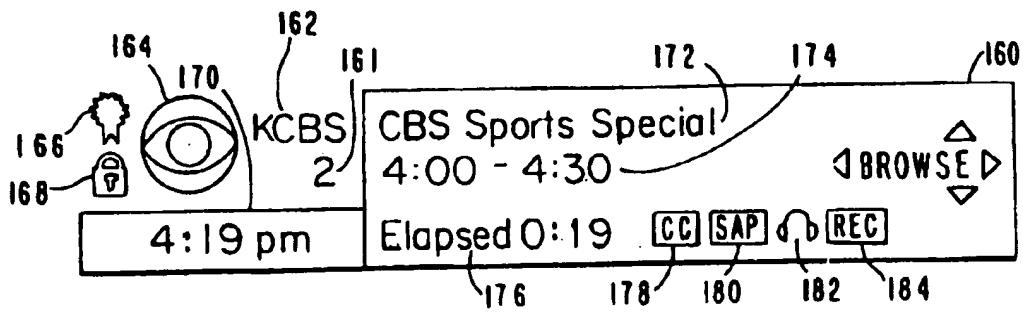


FIG. 8



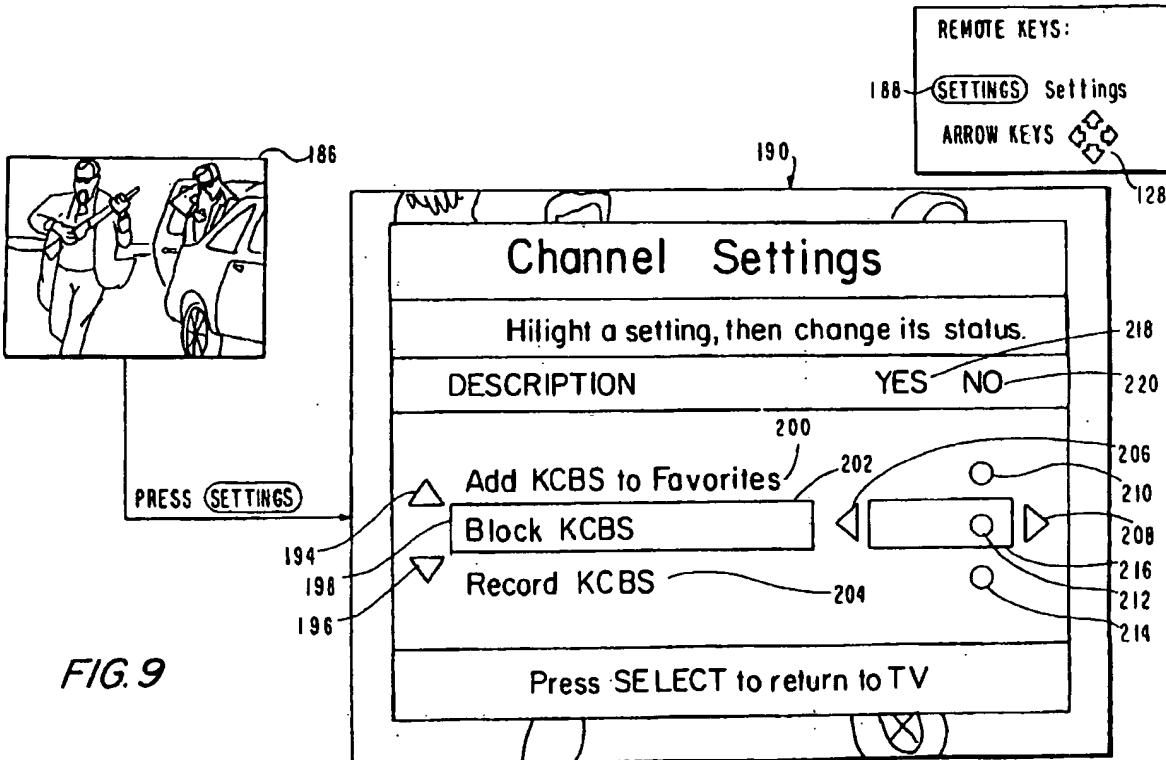
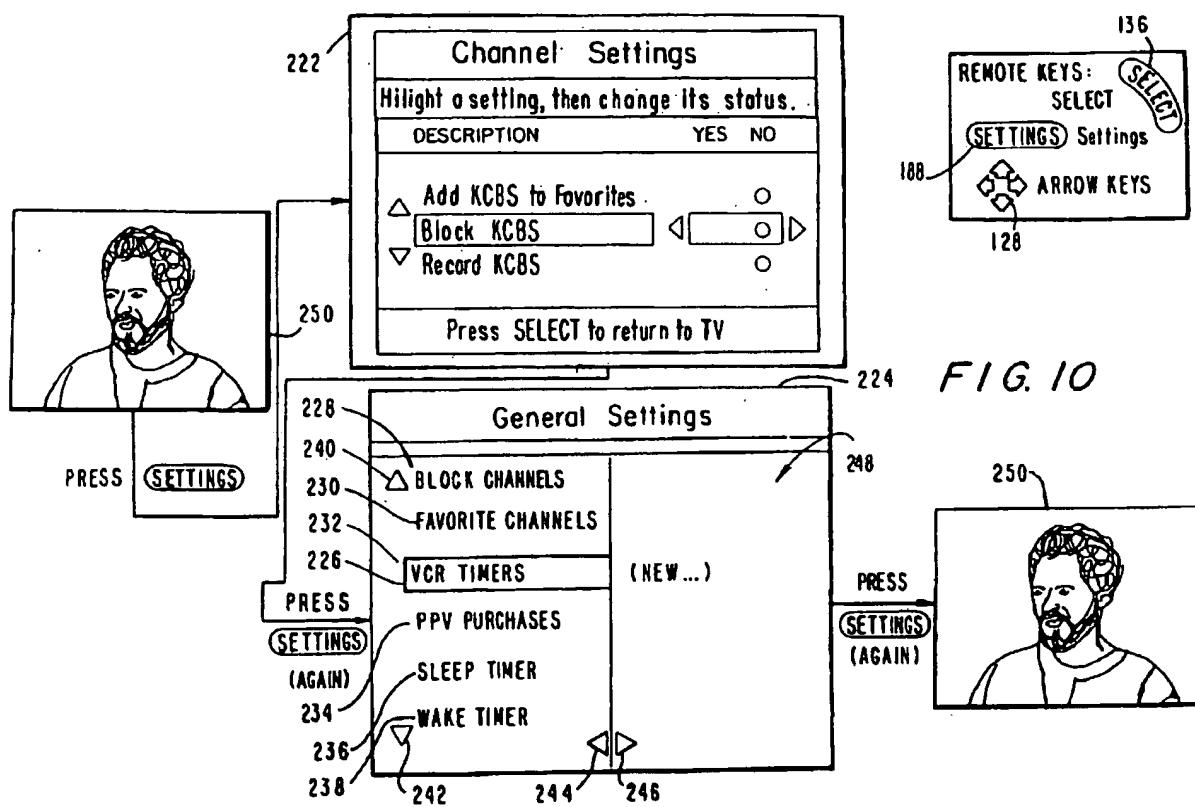


FIG. 9



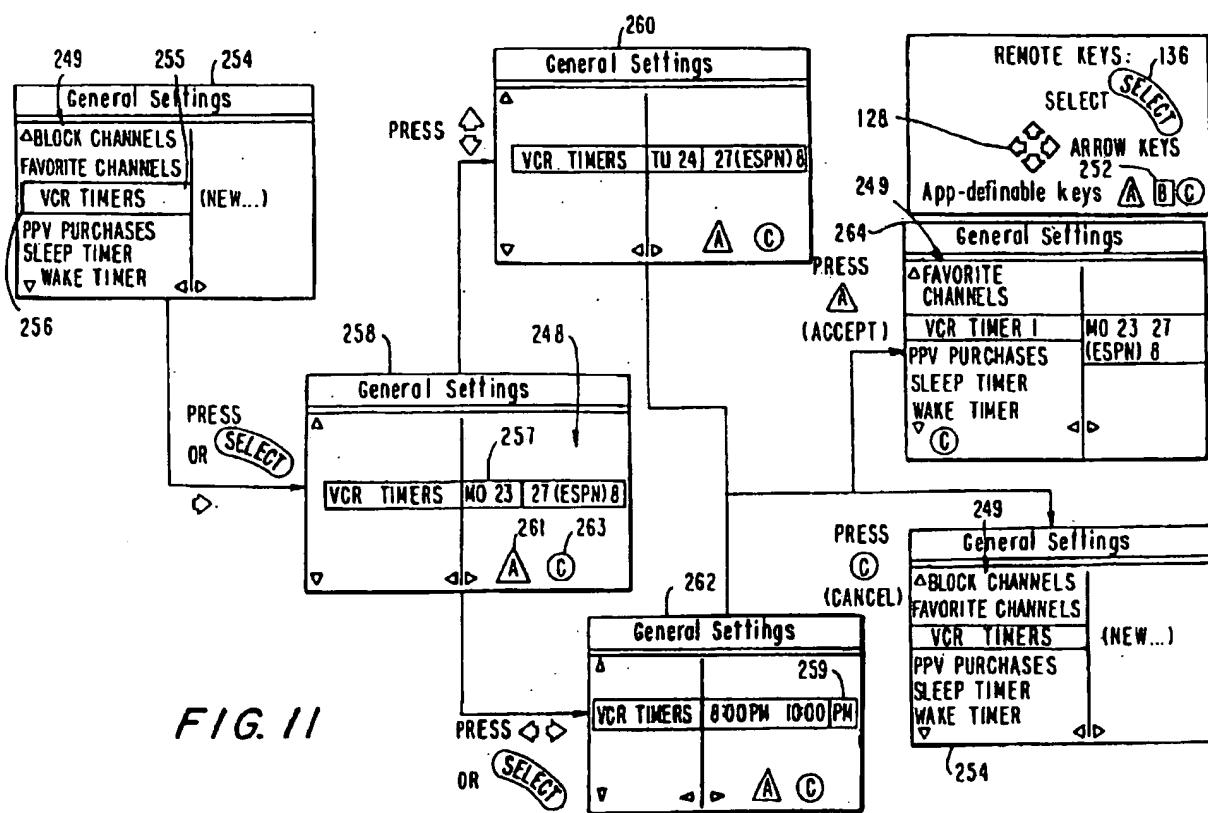


FIG. 12

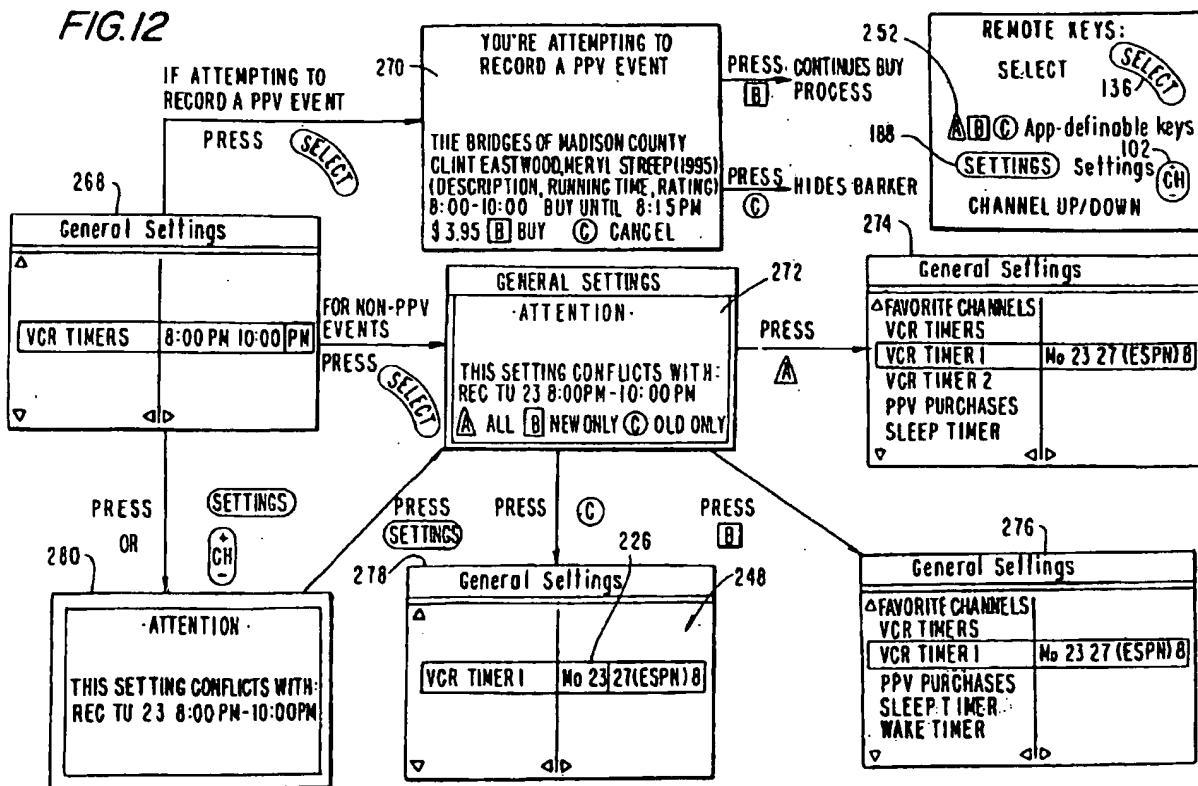


FIG. 13

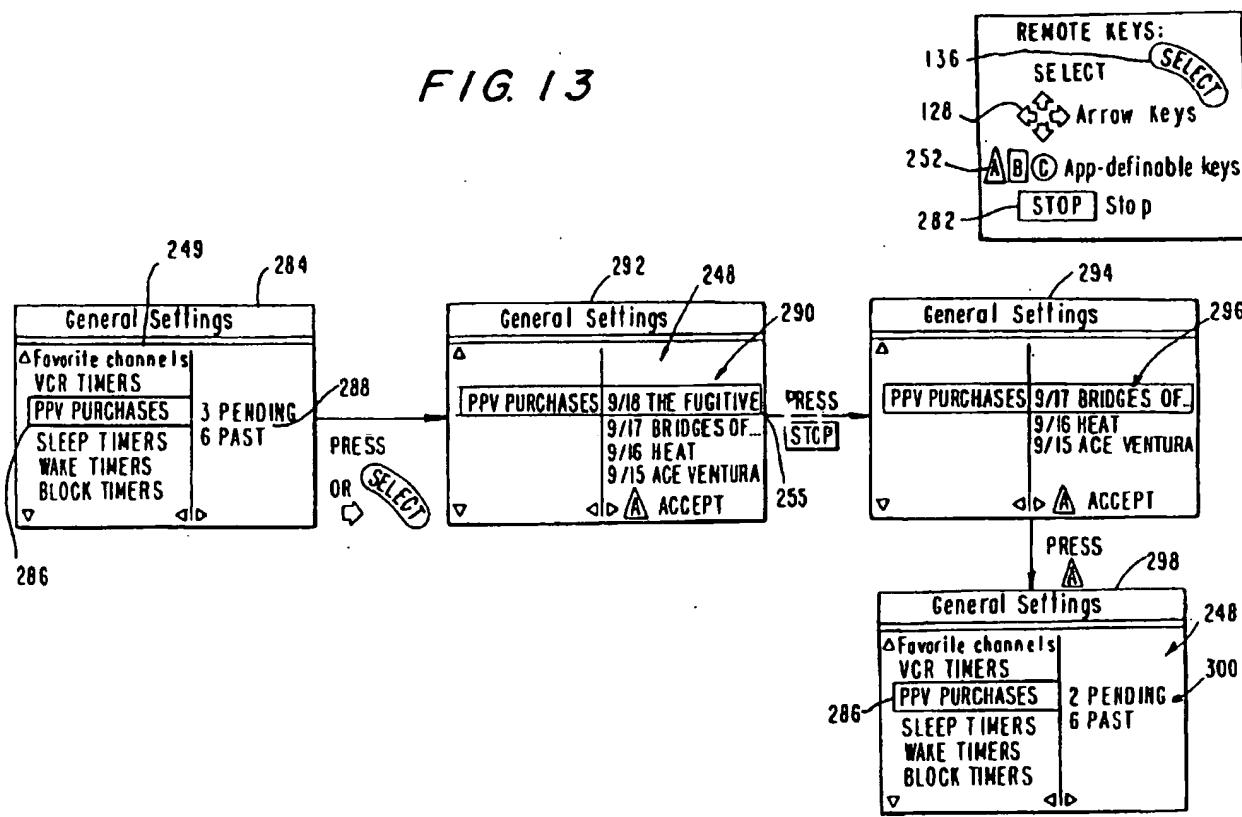


FIG. 145

FIG. 14

322

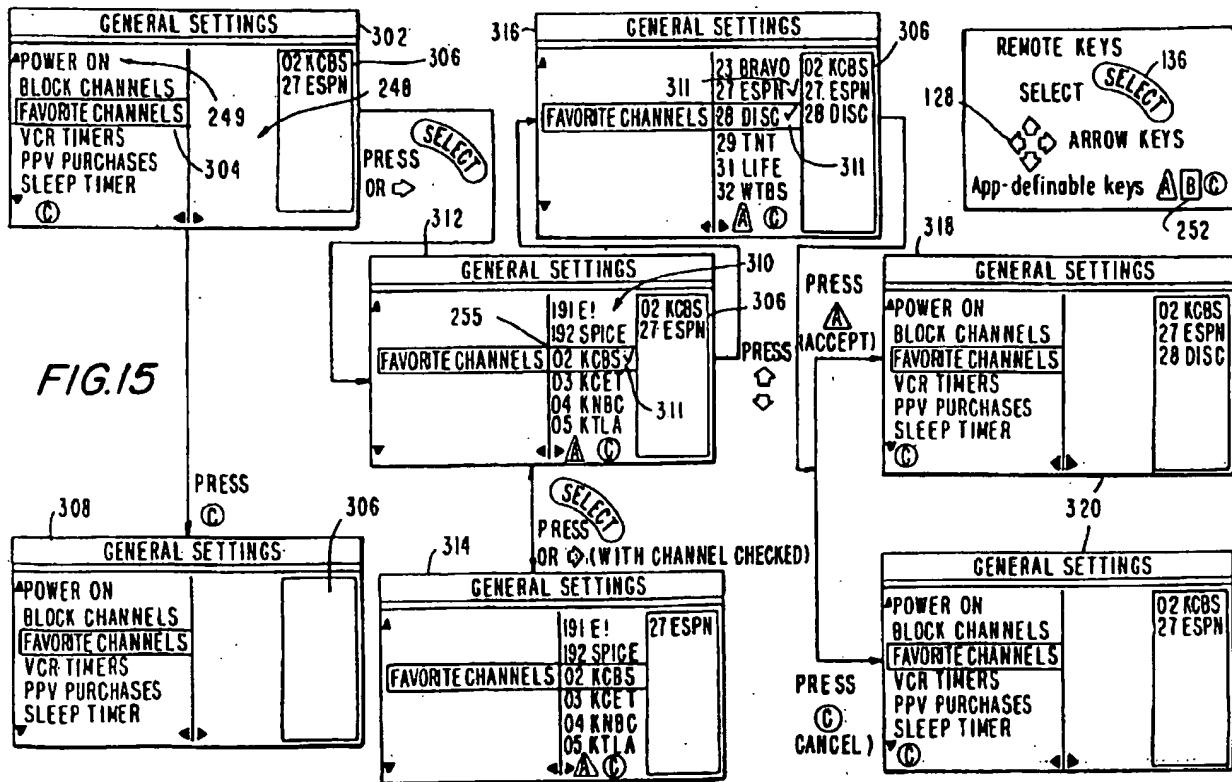
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Use UP/DOWN arrows to review all timers.

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<input checked="" type="checkbox"/> ALL TIMERS	REC Su. 9/15, 2:30-3:30am 75 PPV			
	REC Mo. 9/16, 2:00-3:30pm 2 KCBS			
	@ Mo. 9/16, 4:00-6:00pm 2 KCBS			
	REC Tu. 9/17, 10:00-11:00pm 67 HBO			
	@ Tu. 9/17, 11:00-12:00pm 77 PPV			
	@ Fr. 9/20, 3:58-5:30pm 23 ESPN			
REC Sa. 9/21, 5:00-6:00pm 4 KNBC				

Accept

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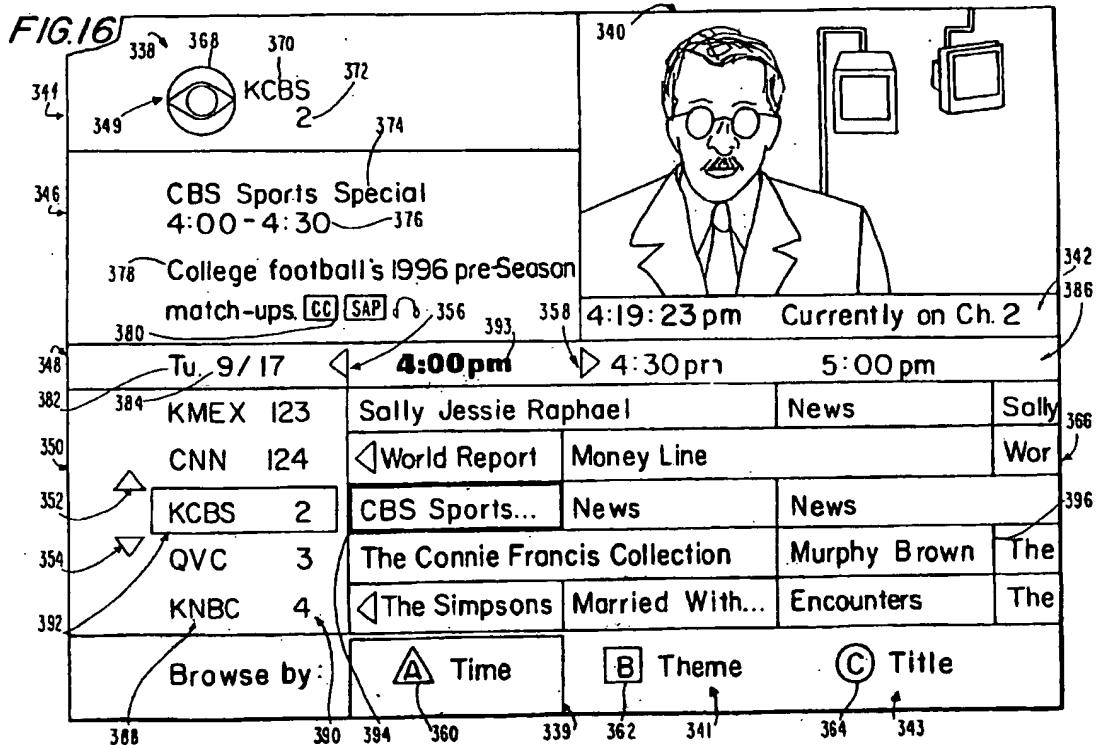
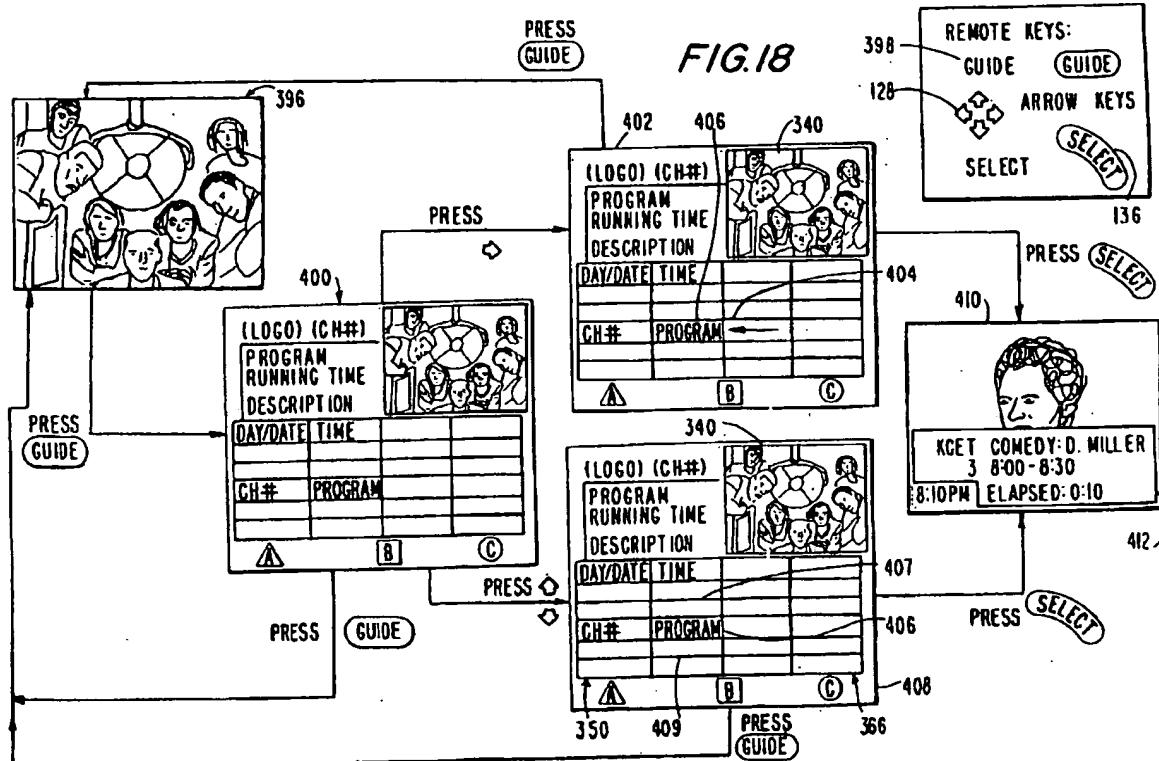
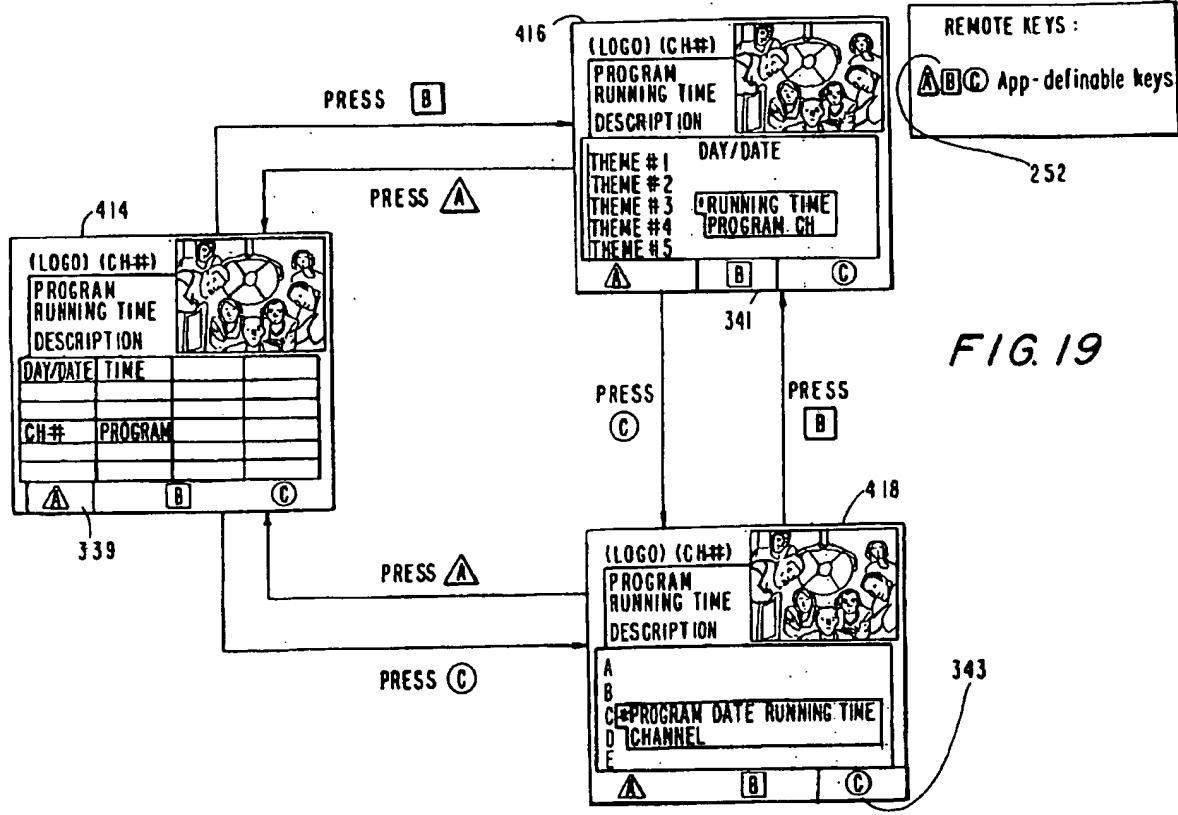


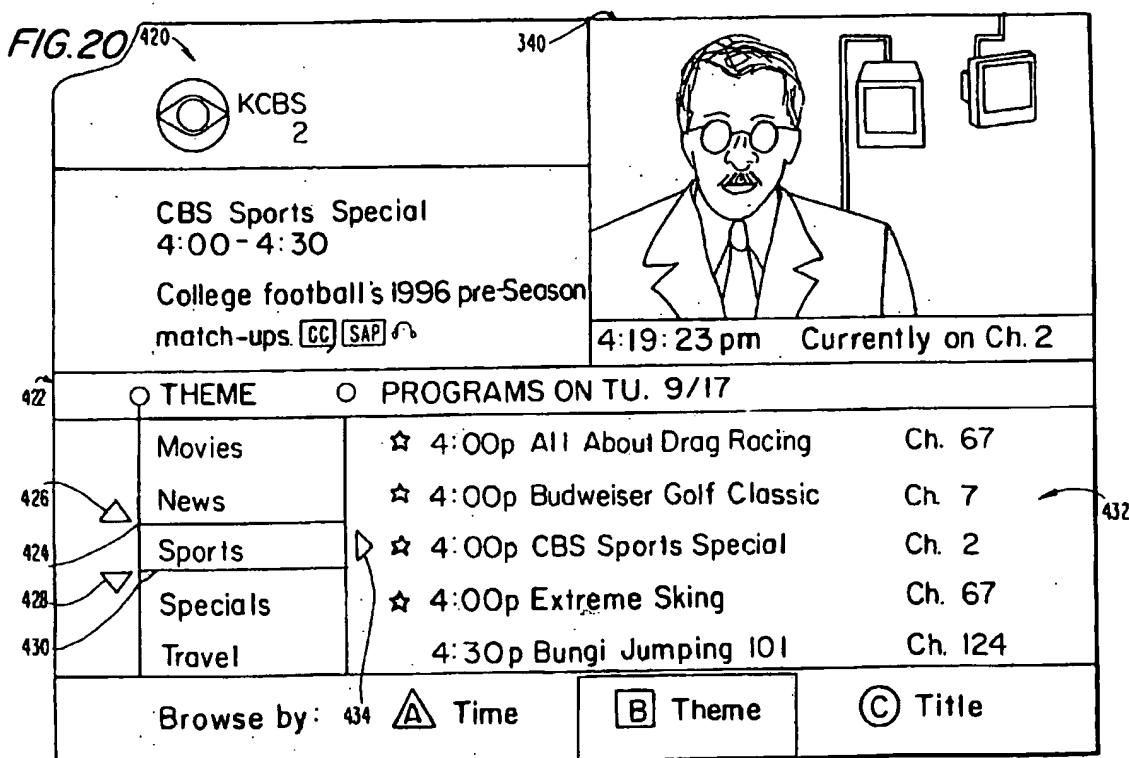
FIG. 17

361	Bravo BRAV 147	 <p>4:19:23 pm Currently on Ch. 2</p>		
	New York Ballet 4:00 - 4:30 New York Ballet Company presents "The Nutcracker"			
	Tu. 9/17 < 4:00pm > 4:30 pm 5:00pm			
363	KMEX 123	Sally Jessie Raphael	News	Sally
	CNN 124	<World Report	Money Line	Wor
365	BRAV 147	New York Ballet	Rembrandt	OFF AIR
	LIFE 147	OFF AIR	Your Health	Pets
	KNBC 4	<The Simpsons	Married With...	Encounters
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366







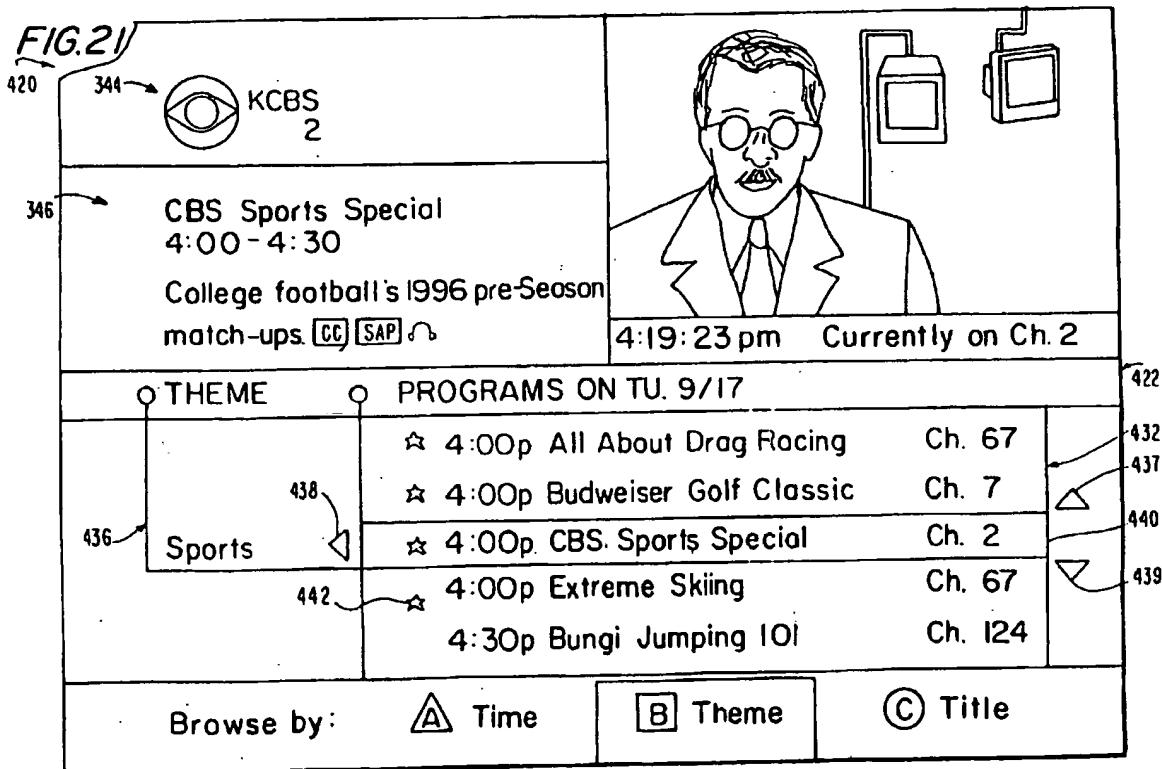
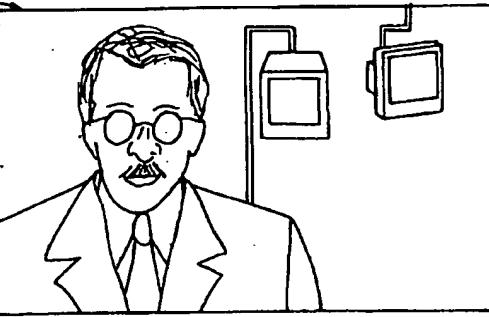
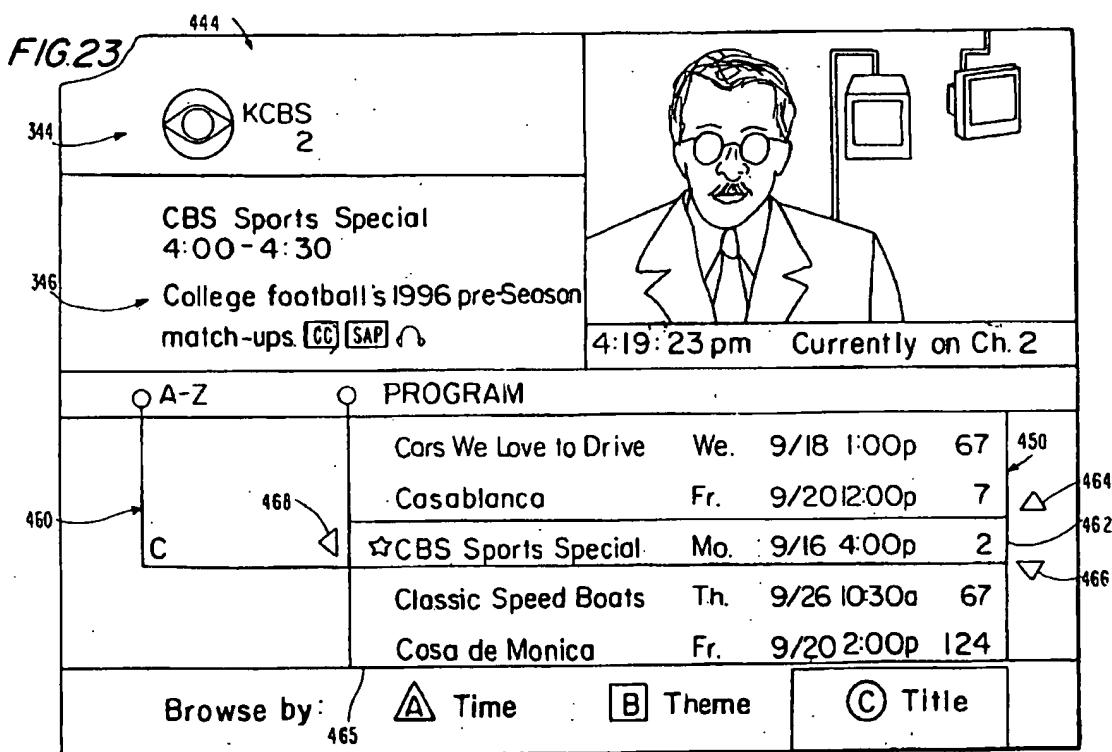
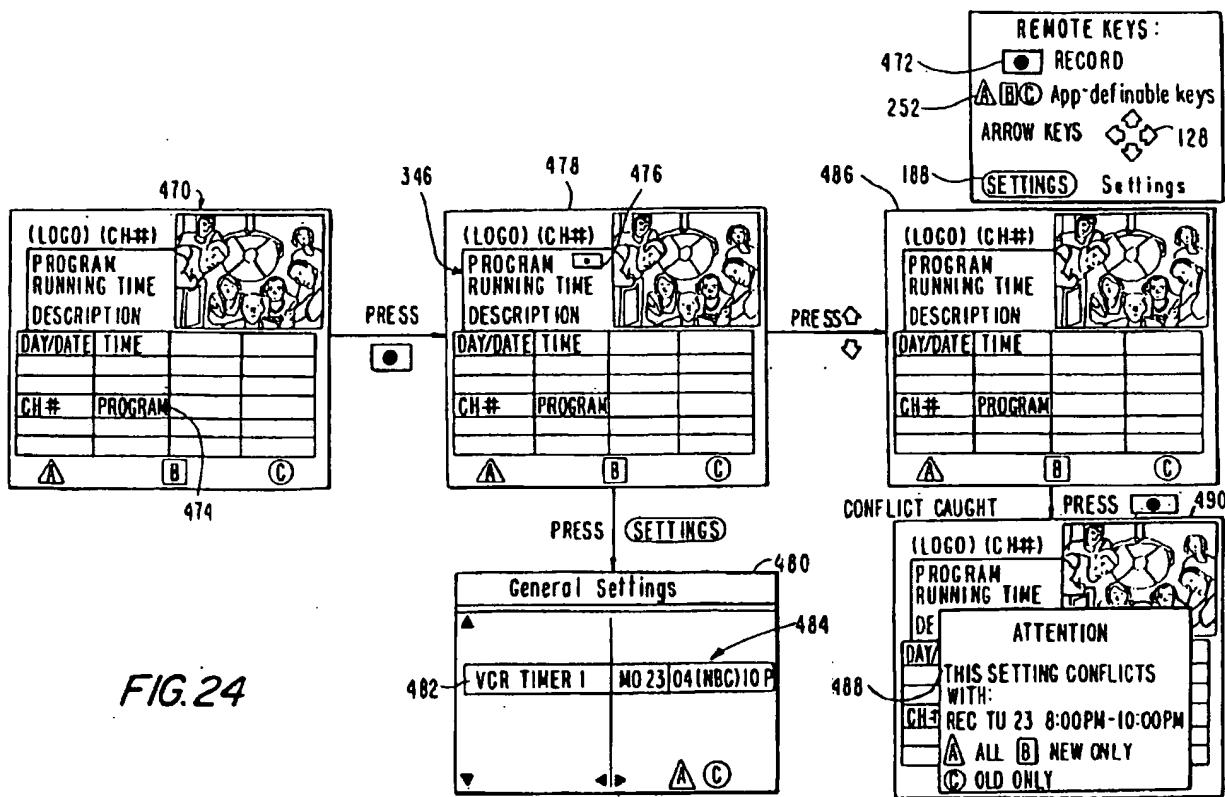


FIG.22)

444 KCBS 2	340																			
<p>CBS Sports Special 4:00 - 4:30 College football's 1996 pre-Season match-ups. [CC] [SAP] ⏪</p>		4:19:23 pm Currently on Ch. 2																		
<p>446 O A-Z O PROGRAM</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 20%;">448</th> <th style="width: 60%;">450</th> <th style="width: 20%;">452</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>Cars We Love to Drive We. 9/18 1:00p 67</td> <td></td> </tr> <tr> <td>B</td> <td>Casablanca Fr. 9/20 12:00p 7</td> <td></td> </tr> <tr> <td>C</td> <td>☆CBS Sports Special Mo. 9/16 4:00p 2</td> <td></td> </tr> <tr> <td>D</td> <td>Classic Speed Boats Th. 9/26 10:30a 67</td> <td></td> </tr> <tr> <td>E</td> <td>Casa de Monica Fr. 9/20 2:00p 124</td> <td></td> </tr> </tbody> </table> <p>454 Browse by: 456 ▲ Time ■ Theme ○ Title</p>			448	450	452	A	Cars We Love to Drive We. 9/18 1:00p 67		B	Casablanca Fr. 9/20 12:00p 7		C	☆CBS Sports Special Mo. 9/16 4:00p 2		D	Classic Speed Boats Th. 9/26 10:30a 67		E	Casa de Monica Fr. 9/20 2:00p 124	
448	450	452																		
A	Cars We Love to Drive We. 9/18 1:00p 67																			
B	Casablanca Fr. 9/20 12:00p 7																			
C	☆CBS Sports Special Mo. 9/16 4:00p 2																			
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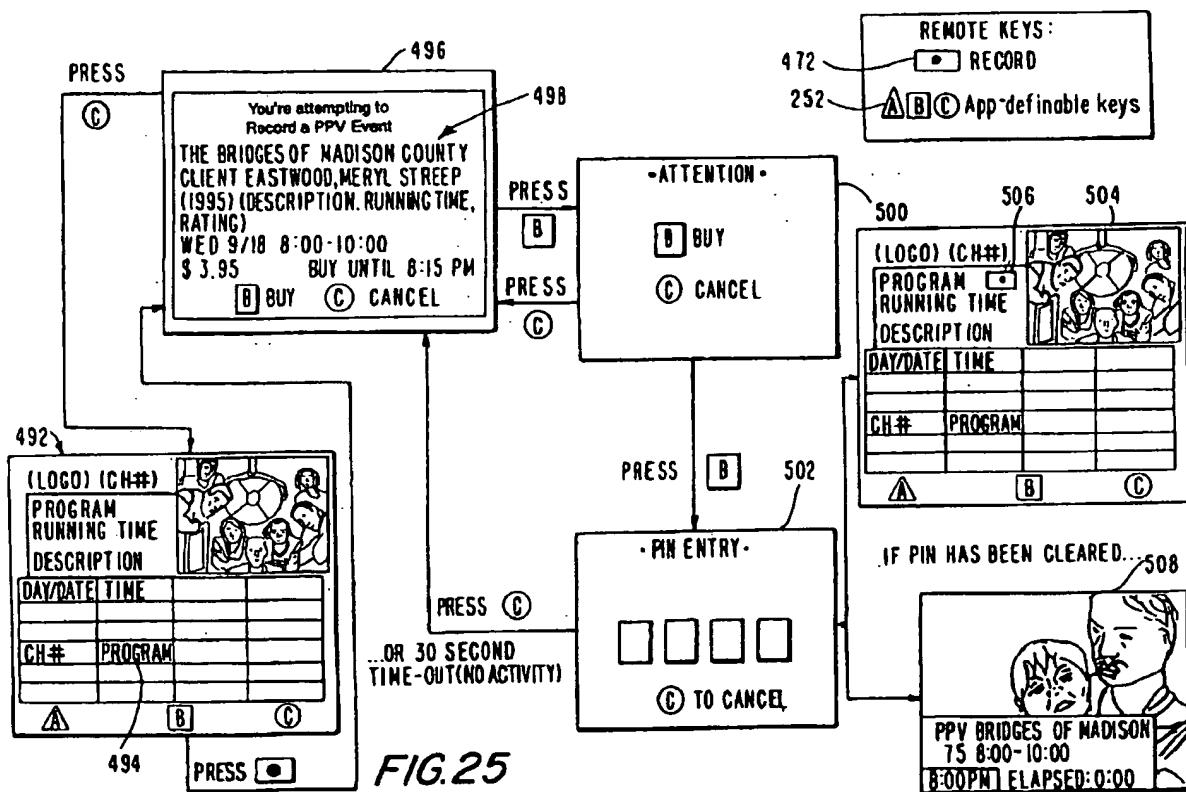


FIG.25

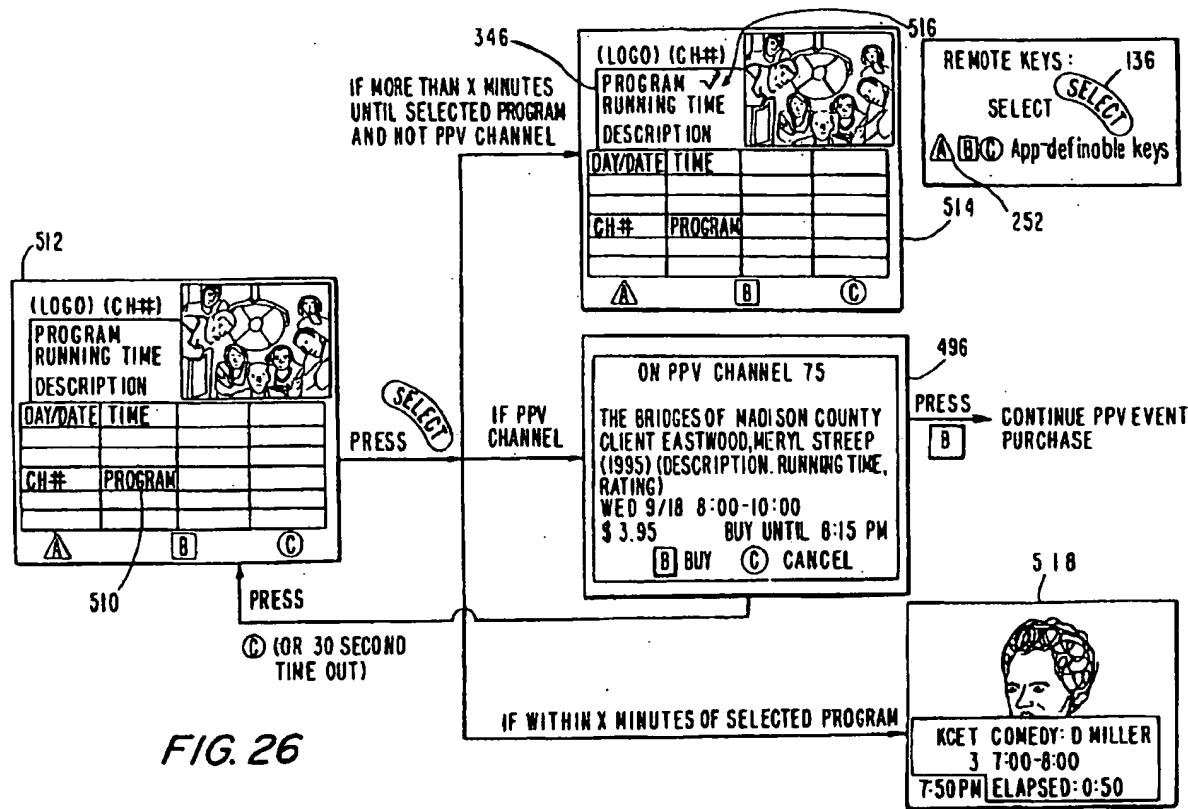


FIG. 26

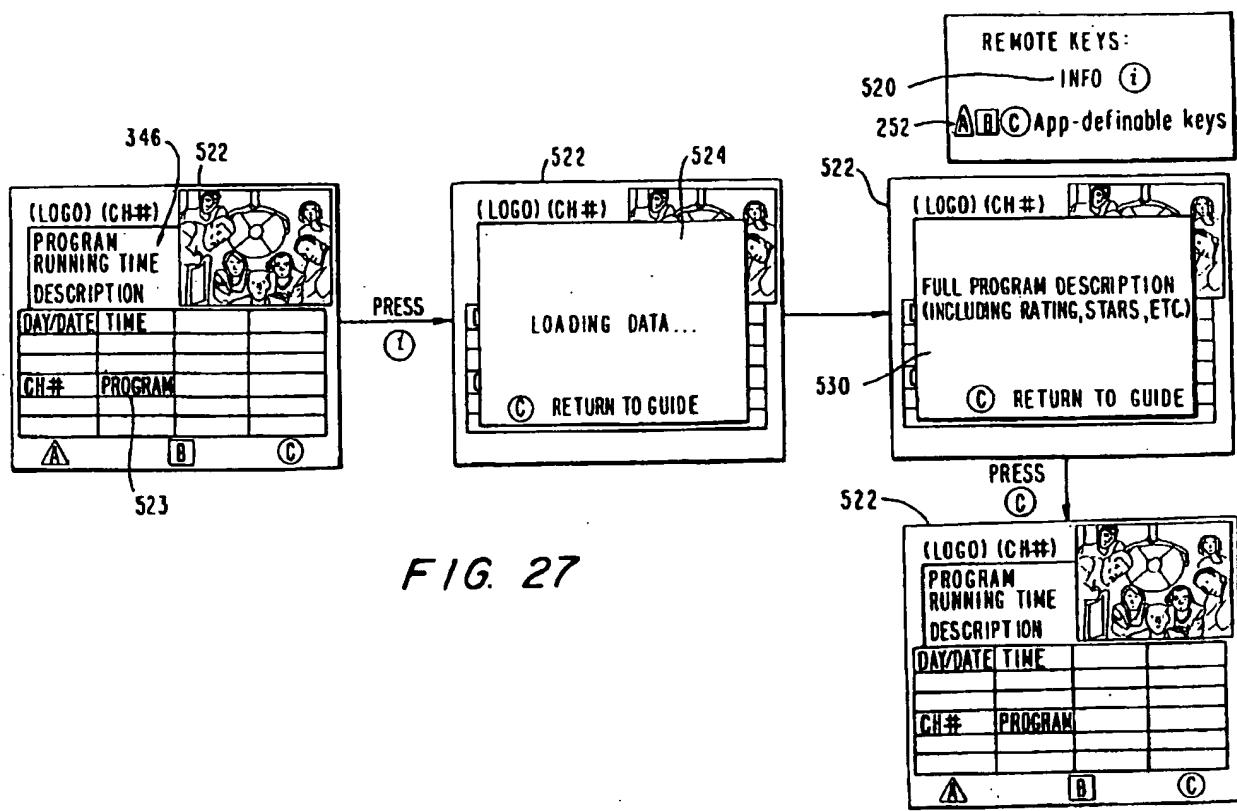


FIG. 27

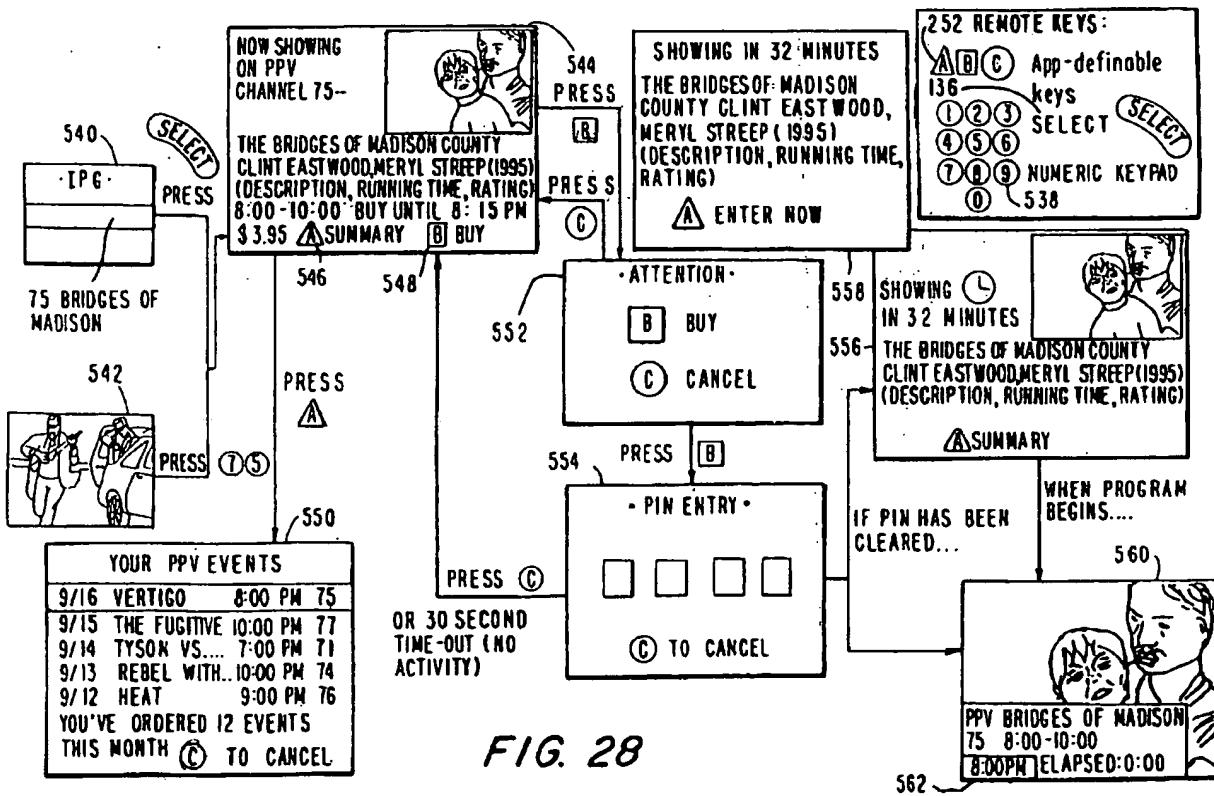


FIG. 28

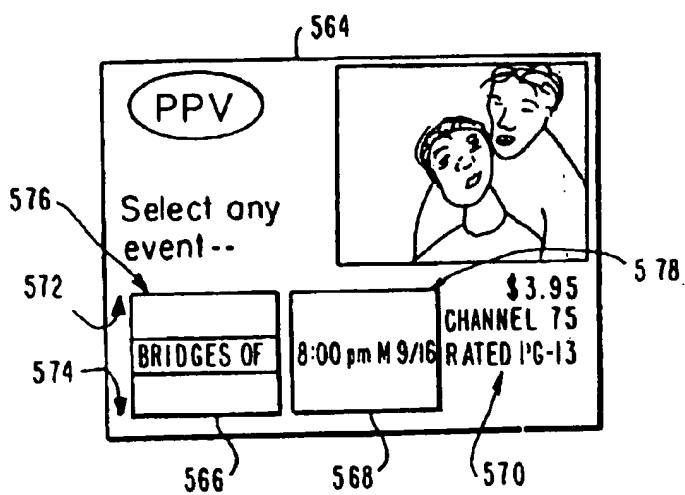
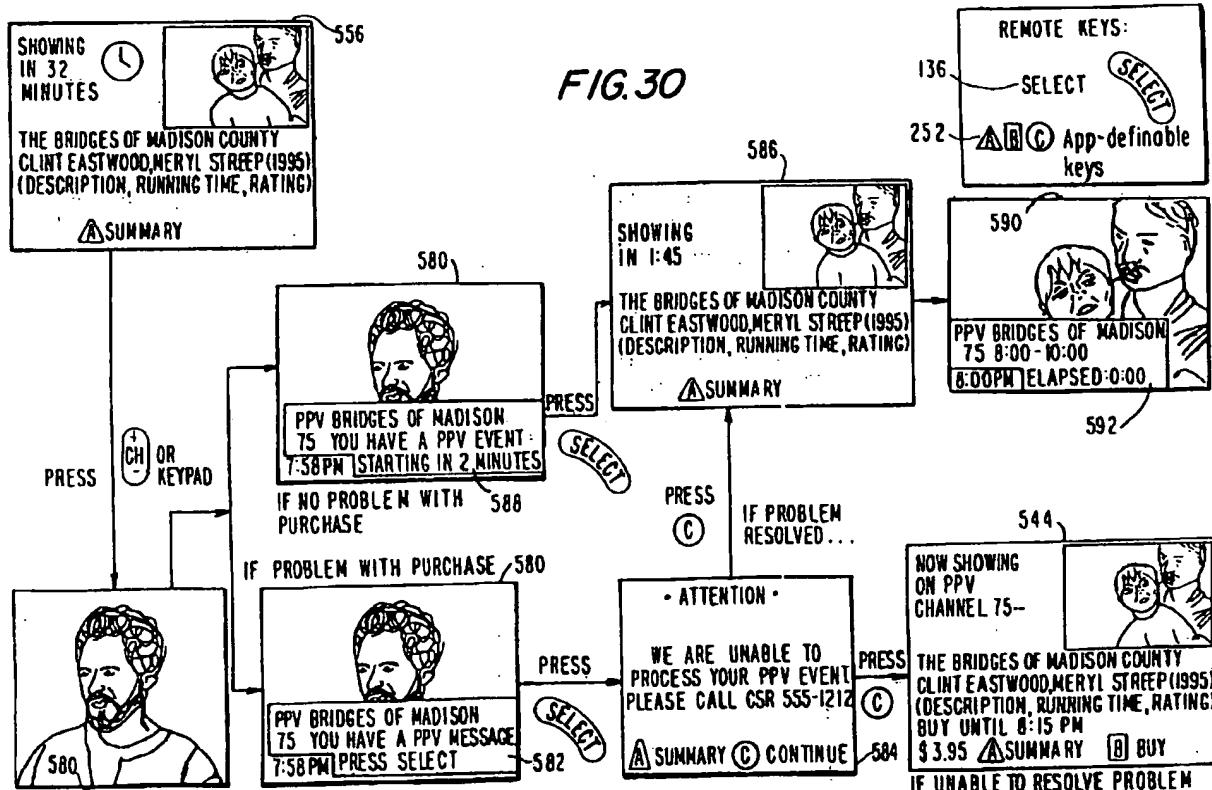


FIG. 29



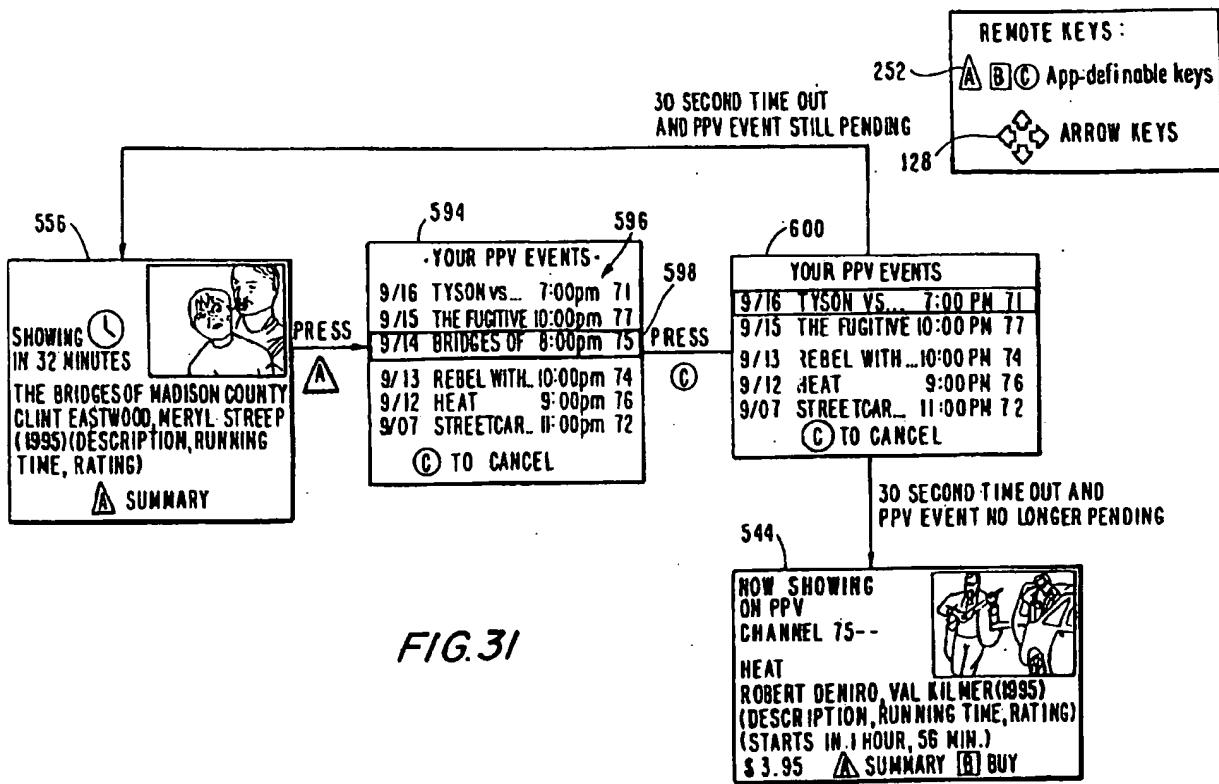


FIG. 31

FIG. 32

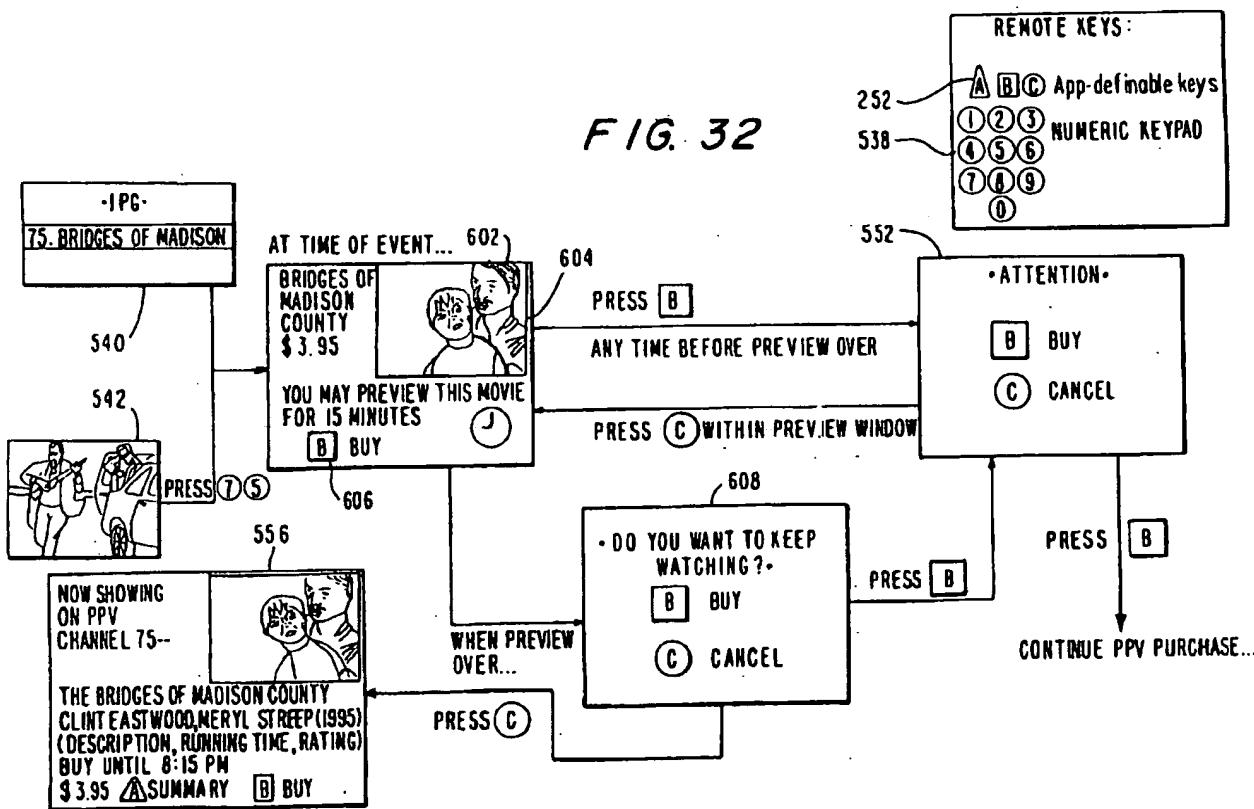


FIG. 33

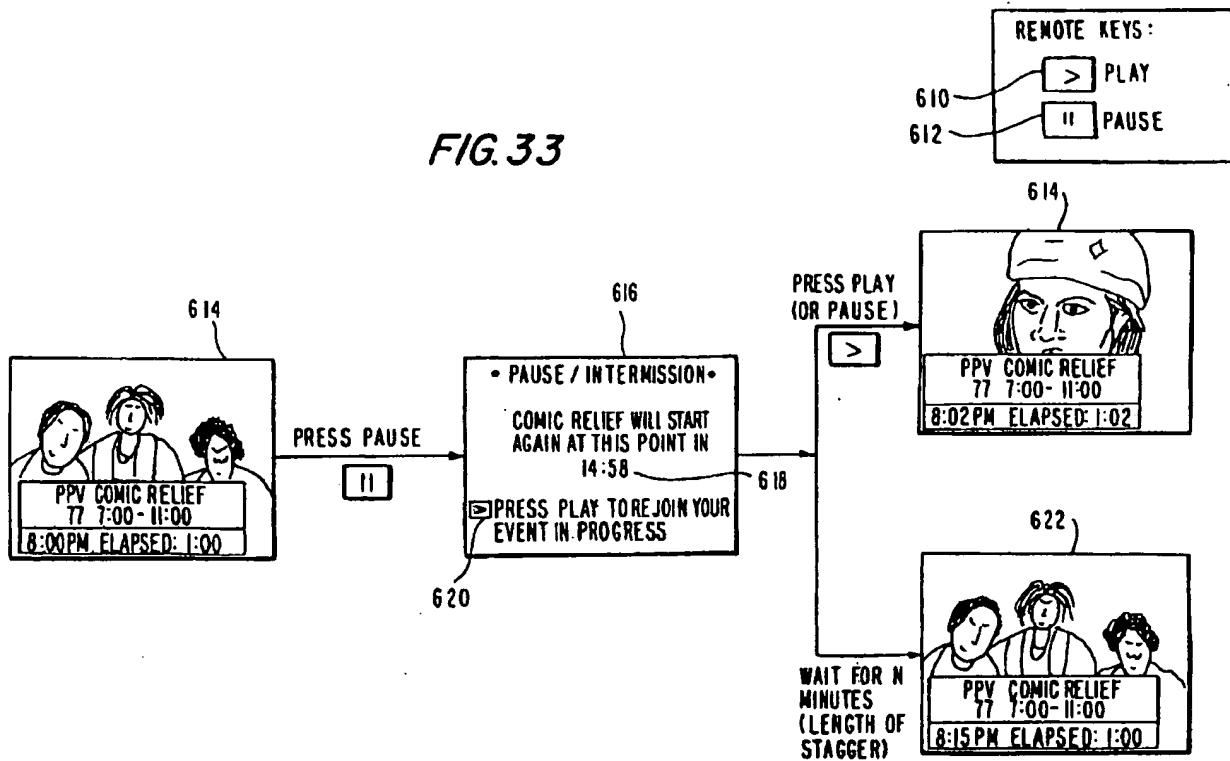
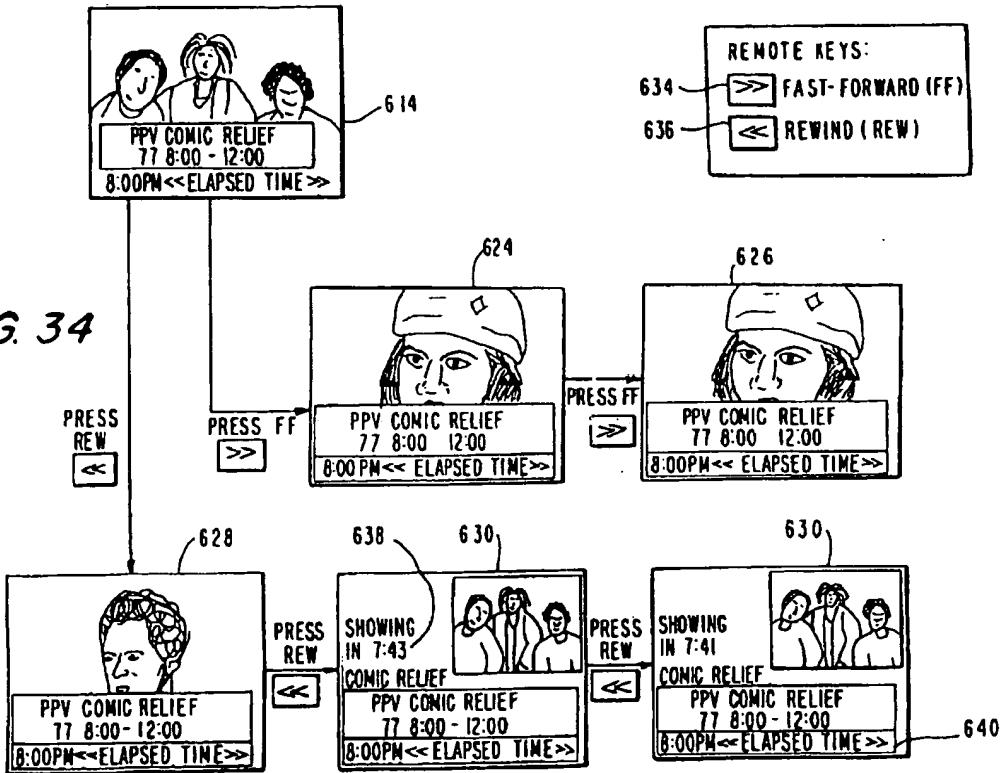


FIG. 34



642-

Emergency Broadcast

An URGENT SITUATION exists in your area.

Press SELECT immediately
for emergency information.
(or tune to Channel 1999)

644



Emergency Information

FIG. 35

**INTERACTIVE PROGRAM GUIDE FOR
DESIGNATING INFORMATION ON AN
INTERACTIVE PROGRAM GUIDE DISPLAY**

**CROSS REFERENCE TO RELATED
APPLICATION**

This is a continuation of commonly assigned U.S. patent application Ser. No. 08/802,833, filed Feb. 19, 1997, now U.S. Pat. No. 5,850,218.

BACKGROUND OF THE INVENTION

This invention relates generally to television systems. More particularly, this invention relates to full service television systems that use advanced storage, communications, and processing techniques to provide a variety of television services including audio and audiovisual programming, advanced navigation controls, interactive program guides, Impulse Pay-Per-View activation, Near-Video-On-Demand programming, Video-On-Demand programming, advanced configuration controls, and online services.

With recent advances in storage, communication, and processing technologies, many present-day television systems are becoming antiquated. This is especially true of many cable television systems. Traditional methods of broadcasting television programs and services in such cable television systems suffer from an inability to deliver a high number of high quality television signals on a single coaxial cable. Many existing television systems also cannot provide the advanced television services desired by their subscribers, such as, for example, a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On-Demand programming, Video-On-Demand programming, and advanced configuration controls. Furthermore, most modern television systems have no provisions whatsoever for supplying services such as World Wide Web browsing, Internet E-Mail, and online services.

In view of the foregoing, it would be desirable to provide a full service television system capable of delivering a high number of high quality television signals.

It would also be desirable to provide a full service television system capable of using advanced communication techniques to deliver a high number of high quality television signals.

It would further be desirable to provide a full service television system capable of sustaining two-way communication between a cable service provider and a cable service subscriber.

It would even further be desirable to provide a full service television system capable of delivering advanced television services such as a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On-Demand programming, Video-On-Demand programming, and advanced configuration controls.

It would still further be desirable to provide a full service television system capable of delivering services such as World Wide Web browsing, Internet E-Mail, and online services.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide a full service television system capable of delivering a high number of high quality television signals.

It is also an object of this invention to provide a full service television system capable of using advanced com-

munication techniques to deliver a high number of high quality television signals.

It is a further object of this invention to provide a full service television system capable of sustaining two-way communication between a cable service provider and a cable service subscriber.

It is a still further object of this invention to provide a full service television system capable of delivering advanced television services such as a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On-Demand programming, Video-On-Demand programming, and advanced configuration controls.

It is an even further object of this invention to provide a full service television system capable of delivering services such as World Wide Web browsing, Internet E-Mail, and online services.

In accordance with these and other objects of the present invention, a full service television system is provided that includes digital and analog programs and services, an advanced communications network, and a fully programmable set-top terminal capable of implementing advanced television and online services.

In the preferred embodiments of the present invention, the full service television system is implemented as a cable television system. Although a cable television system is described herein, the present invention, and all of its features, may be implemented in other forms, such as, for example, a Direct Broadcast Satellite (DBS) system, a Multi-channel Multi-point Distribution System (MMDS), an Asymmetric Digital Subscriber Loop (ADSL) system, a Local Area Network (LAN) system, or a Wide Area Network (WAN) system.

Preferred implementations of the cable television system of the present invention include a cable headend, at least one fiber transport, at least one distribution hub, at least one hybrid fiber coax plant, and a plurality of set-top terminals. The cable headend provides programs, services, and overall system control of the cable television system. The fiber transports, distribution hubs, and hybrid fiber coax plants provide an advanced communication network for the cable television system. The set-top terminals provide interfaces, processing, and storage capability in a subscriber's home to facilitate the implementation of advanced television and online services.

To provide programs, services, and overall system control of the cable television system of the preferred embodiments of the present invention, the cable headend incorporates digital and analog satellite receivers, a broadcast cable gateway, integrated receiver decoders, analog scrambling and modulation, application and media servers, an addressable controller, a digital switch or multiplexer, and an interactive cable gateway. Although these elements will be described herein as distinct functions, each can be implemented as a portion of a single device, as a single device, or as a composition of devices.

Programs and services provided by the cable headend are supplied to the cable headend primarily through analog and digital satellite broadcasts and through digital data storage. The cable headend may also receive programs and services from sources such as, for example, analog off-air signals, digital off-air signals, and locally originated signals.

Analog and digital satellite broadcasts are received at the cable headend by a plurality of analog and digital satellite receivers. Integrated receiver decoders within the cable headend control the reception of the analog satellite

broadcasts, and analog scrambling and modulation converts the analog signals into a format suitable for transmission over the cable system's communication network. Similarly, a broadcast cable gateway within the cable headend controls the reception of the digital satellite broadcasts and converts the digital signals into a format suitable for transmission over the cable system's communication network.

Programs and services are also supplied to the cable headend through digitally stored data in application and media servers. Programs and services stored in the application and media servers are first transmitted to the cable system's communication network through a digital switch or multiplexer and then through an interactive cable gateway. The digital switch or multiplexer can be implemented through an Asynchronous Transfer Mode switch, a Digital Video Broadcast Asynchronous Serial Interface (DVB ASI), or other suitable means. The application servers can be connected directly to the digital switch or multiplexer, or can be connected to the digital switch or multiplexer via an intermediate network. The media servers, however, should preferably be connected to the digital switch or multiplexer directly because of the high bandwidth requirements of the media servers and the limited bandwidth capabilities of present day networks. Programs and services transmitted through the digital switch or multiplexer from the application and media servers are converted by the interactive cable gateway to a format suitable for transmission in the cable system's communication network. By connecting the application and media servers to the interactive cable gateway through the digital switch or multiplexer, a cable system operator can add new application and media servers to the cable television system as needed.

Overall system control is provided by the cable headend primarily through an addressable controller. The functions performed by the addressable controller can include, for example, control of all equipment interaction at the cable headend, management of the cable television system's communication network, control of all equipment located in the system's communication network, configuration and management of set-top terminals (preferably both those of the present invention and those that may later be introduced into the marketplace), operational control of the distribution hubs, operational control of the interactive cable gateway, and distribution control of programs and services from the integrated receiver decoders, broadcast cable gateway, application servers, and media servers to the set-top terminals.

The communication network of the cable television systems of the preferred embodiments of the present invention includes at least one fiber transport, at least one distribution hub, and at least one hybrid fiber coax plant. The communication network preferably includes analog channels with vertical blanking interval (VBI) signals, forward application transport (FAT) channels, forward data channels (FDC), and reverse data channels (RDC). Analog channels with VBI signals maintain downward compatibility with existing cable television equipment. FAT channels provide set-top terminals with compressed digital content such as, for example, video, audio, applications, control message, and broadcast data. Forward data channels carry to the set-top terminals out-of-band Internet protocol (IP) datagrams containing messages regarding, for example, conditional access, entitlement, broadcast data, network management, application downloads, variable bit-rate (VBR) downloads, external device data services, or general matters. Furthermore, all interactive program guide data is carried to the set-top terminals exclusively over the out-of-band forward data

channels. Reverse data channels carry IP datagram messages from the set-top terminals to equipment within the cable headend. These messages can relate to, for example, network management, external device data services, program/service control and activation, or general matters.

The fiber transports carry signals between the cable headend and the distribution hubs and are preferably each physically configured in a ring connecting typically five distribution hubs to the cable headend. Each of the fiber transports includes a bundle of at least one fiber optic cable, at least one of which is used by each distribution hub on the physical ring of each fiber transport. By using selected fiber optic cables within the fiber transport's bundle, the distribution hubs may be connected to the cable headend either through adjacent hubs in a logical "ring" configuration, directly to the headend in a logical "star" configuration, or in any other logical configuration.

The distribution hubs comprise a plurality of data channel gateways, each of which receives and transmits data messages between the cable headend and the set-top terminals. The data channel gateways provide routing functions, modulation functions on the signals to the set-top terminals, and demodulation functions on the signals from the set-top terminals. The routing, modulation, and demodulation functions performed by the data channel gateways are all controllable by the addressable controller within the cable headend.

The hybrid fiber coax plants connect the distribution hubs to the set-top terminals and each includes fiber optic cable, a node, and a plurality of coaxial cables. The node in each hybrid fiber coax plant converts optical signals to electrical signals and electrical signals to optical signals such that two-way communication is maintained over the fiber optic and coaxial cables connecting the distribution hubs and set-top terminals.

The digital and analog programs and services furnished by the cable headend are presented to cable subscribers by set-top terminals within their homes. In the preferred embodiments of the present invention, the set-top terminals each include a central processing unit, memory, a memory management unit, communications circuitry, I/O control circuitry, and audio and video output circuitry. Each set-top terminal is controlled by the central processing unit which executes operating system and application software stored within memory. The memory management unit simplifies and oversees the interaction between the central processing unit and memory. Communication circuitry in the set-top terminal receives, demodulates, decrypts, decodes, and descrambles programs and services transmitted by the cable headend. Additionally, the communication circuitry also controls the two-way digital data transmissions between the headend and the set-top terminal. Input/output (I/O) control circuitry controls subscriber interaction with the set-top terminal through a keypad, an LED display, and a remote control. The I/O control circuitry also interfaces the set-top terminal with an accessories bus and external equipment (e.g., via an I/R transmitter), and is compatible with known interfaces, such as, for example, Ethernet 10-base-T, P1394, and SPDIF. Audio and video control circuitry in each set-top terminal provides graphics generation, audio synthesis, and real-time -digital video processing, and generates the outputs necessary to interface the set-top terminal with a subscriber's home audio and video system. These audio and video outputs can include, for example, AC-3 audio, baseband audio, RF video, S-Video, and baseband video outputs.

In the preferred embodiments of the present invention, application software within the set-top terminal provides the

advanced cable services desired by many cable subscribers. These services include a comprehensive channel navigator, an interactive program guide, Impulse Pay-Per-View activation, Near-Video-On Demand programming, Video-On-Demand programming, and advanced configuration controls. Additionally, because the set-top terminal is upgradable via software downloads from the cable headend, new services can be added to the set-top terminal as they become available.

The comprehensive channel navigation controls provided by the application software of the set-top terminal enable a subscriber to more easily navigate through the abundance of programming and services that are available in the preferred embodiments of the present invention. For example, a program information banner can be displayed whenever a subscriber changes channels to identify the program currently being displayed on the selected channel. This banner can include the following: the channel's call sign, number, and logo; the program's name, running time, and elapsed time; the current time; a brief description of the program; information regarding the next program on that channel; or any other information that may be of interest to the subscriber.

The navigation controls of the preferred embodiments of the present invention provide a channel selection function that includes a plurality of tables that cross reference channel numbers with the type, source, parameters, and description of the various television services (e.g., audio and video programming and online services) provided by the cable system. These tables create levels of control, transparent to the subscriber, that allow the set-top terminal to identify the parameters and software needed to activate the program or service associated with a selected channel number. For example, if a subscriber selects channel 10, which is associated with an E-mail service, the set-top terminal accesses the cross-reference tables to identify the type and source of the television service associated with channel 10. The set-top terminal then obtains from the tables any necessary parameters and executes the appropriate E-mail software to activate the selected service. Thus, rather than just map channel numbers to analog broadcast video frequencies as in traditional cable systems, these tables allow channel numbers to be mapped to other sources of data, such as, for example, MPEG video, VBI, IP, and ROM.

Furthermore, unlike traditional cable systems in which channel numbers are fixed to analog broadcast frequencies, these cross-reference tables allow television services to be arranged in any channel number order, regardless of how they are transmitted by the cable system to the set-top terminal. For example, a channel table can be configured to associate channel 4 with video service 3 provided by video source 2 or, alternatively, channel 4 can be associated with music service 12 provided by music source 8. Once a set-top terminal channel number is associated with a particular service, the association is maintained even if the cable provider reassigns the cable channel numbers over which the television services are transmitted.

The preferred embodiments of the present invention also provide channel setting controls which enable a subscriber to fully configure the set-top terminal to operate as desired. For example, the subscriber can assign channels to a favorite channel list; block channels based on channel number, time, program rating, genre, etc.; set timers to record a particular program; turn the set-top terminal on or off at a particular time; or remind the subscriber that a particular program is on or that a tape has to be put in an attached video cassette recorder (VCR).

A browse feature is also provided by the comprehensive navigation controls in the preferred embodiments of the present invention. The browse feature presents a banner that can identify other programs or services that are, were, or will be available for viewing on other channels. Similar to the program information banner described previously, the browse banner can include the following: a channel's call sign, number, and logo; a program's name, running time, and elapsed time; the current time; a brief description of the current program; information regarding a program following the browse program; or any other information that may be of interest to a subscriber.

An interactive program guide within the set-top terminal of the preferred embodiments of the present invention further allows the subscriber to easily operate the set-top terminal and navigate through the abundance of programs and services available in the cable television system. This interactive program guide can include any of at least three main modes: a time mode, a theme mode, and a title mode.

In the time mode, program information is displayed in a grid arrangement with rows preferably corresponding to channel numbers, and columns preferably corresponding to times. By navigating through this grid, a subscriber can identify and review information regarding programs that were, are, or will be available for viewing.

The theme mode of the present invention displays program information of programs that were, are, or will be available for viewing based on a subscriber-selected theme category. Once a theme category has been selected, all programs within that theme are displayed to the subscriber. In some embodiments of the present invention, in addition to scrolling through programs corresponding to a selected theme, a subscriber can also scroll to other themes after reaching the end of the list of programs corresponding to the selected theme.

Similar to the theme mode, the title mode lists and displays information regarding programs available for viewing based on the titles of the programs. Once a first letter is selected, all programs having titles beginning with that letter that were, are, or will be available for viewing are displayed to the subscriber. As with themes, in some embodiments of the present invention, a subscriber is not limited to viewing only those programs with titles beginning with the selected letter, but rather the subscriber may scroll to program titles beginning with other letters once an end of the program titles beginning with the selected letter has been reached.

All modes of the interactive program guide of the preferred embodiments of the present invention can include a highlighted channel banner, a highlighted program summary, a program viewing window, and mode indicators. The highlighted channel banner preferably indicates the call sign, channel number, and channel logo of the channel highlighted in the interactive program guide display. The highlighted program summary preferably indicates the title, running time, description, and characteristics of the program highlighted in the interactive program guide display. The program viewing window can display, for example, any of the following: the program being viewed prior to entering the interactive program guide, a program selected from the interactive program guide, or a program selected at the headend. The content of the program in the program viewing window can include any of the programs or services which can be displayed by the set-top terminal. The program viewing window can also include a time and channel banner indicating the current time and the channel being displayed in the program viewing window. The mode indicators can

indicate the current mode of the interactive program guide and how to activate other available program guide modes.

The interactive program guide of the preferred embodiments of the present invention also facilitates rapid navigation to programs selected by a subscriber. Once the subscriber has found a desired program in the interactive program guide, the subscriber can, by pressing a single key, switch to the program if it is currently being transmitted, set a timer to remind the subscriber of its scheduled transmission, or record the program, either now if currently transmitted or at its scheduled transmission time.

Impulse Pay-Per-View (IPPV) program purchasing is also facilitated in the preferred embodiments of the present invention. Through Impulse Pay-Per-View, a subscriber can request a Pay-Per-View event from the set-top terminal's keypad or remote control. Upon the subscriber selecting an IPPV program, which can be through either the interactive program guide, manual channel selection, or setting of a recording timer, the set-top terminal automatically identifies channels and programs which are IPPV, queries whether the subscriber would like to purchase the selected IPPV program, and authorizes the purchase if the subscriber so indicates. The preferred embodiments of the present invention also allow a subscriber to view summaries of past and currently scheduled IPPV purchases, and to cancel currently scheduled purchases. Additionally, the IPPV features of the preferred embodiments of present invention provide free preview screening of IPPV events, countdown timers to the start of an IPPV event, and automatic reminders if the subscriber has changed channels between the time of ordering and the start time of the IPPV event.

Near-Video-On-Demand (NVOD) can also be implemented in the preferred embodiments of the present invention. NVOD programming transmits each NVOD program from a plurality of sources, each source transmitting the same NVOD program at a fixed time period out of phase with the others. Upon a request to view an NVOD program, the set-top terminal displays on an NVOD channel the source that will next begin transmitting the selected NVOD program based on when the subscriber chooses to view the program.

NVOD programming can simulate the VCR functions of pausing, fast forwarding, and rewinding. This is accomplished by switching the NVOD channel to another NVOD program source. For example, to pause an NVOD program, the set-top terminal displays a pause "barker" (e.g., on-screen message) for the time period between consecutive out-of-phase transmissions of the NVOD program. Once the time period has passed, the set-top terminal switches to the source that began transmitting the program one time period after the previously displayed source's transmission. The NVOD program thus resumes at the point where paused and appears to the subscriber to have been paused by that time period. Similarly, fast forwarding and rewinding are accomplished by switching directly to another NVOD program source. For example, fast forwarding switches to a source that began transmitting the program before the currently viewed transmission, and rewinding switches to a source that began transmitting the program after the currently viewed transmission. By switching to a different NVOD program source, the NVOD program appears to have jumped by the time period between transmissions.

Video-On-Demand (VOD) programming can also be implemented in the preferred embodiments of the present invention. VOD is facilitated primarily by the media servers' ability to deliver high-speed digital data to subscribers'

set-top terminals. Upon a subscriber's request to view a VOD event, a media server capable of delivering the VOD event begins digitally transmitting the program to the subscriber's set-top terminal. Unlike traditional broadcasts, this transmission is typically received only by the subscriber who requested the VOD event. A subscriber can therefore view the program at any time, and can also pause, fast forward, or rewind the program being transmitted.

Finally, the preferred embodiments of the present invention also allow messages to be transmitted to one or more subscribers. These messages can be sent to all subscribers (e.g., an emergency broadcast message) or to only one subscriber (e.g., an unpaid balance message). This message system can also send messages from one party within a household to another (e.g., an instruction by a parent to a child) or from one household to another. Thus a local messaging system within the cable system's community can be established. Additionally, these messages can be configured to activate a service at a subscriber's set-top terminal. For example, a set-top terminal can be automatically turned on to display an emergency news broadcast upon receipt of a message from the headend. Thus a subscriber can be alerted by the set-top terminal at any time, regardless of whether the set-top terminal is on or not.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages of the present invention will be apparent upon consideration of the following detailed description, taken in conjunction with the accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

FIG. 1 is a block diagram of a cable television system of a preferred embodiment of the present invention;

FIG. 2 is a schematic diagram of a cable television system of a preferred embodiment of the present invention;

FIG. 3 is a block diagram of a set-top terminal of a preferred embodiment of the present invention;

FIG. 4 is a flow diagram of a channel navigation function of a set-top terminal of a preferred embodiment of the present invention;

FIG. 5 is a data structure diagram illustrating a channel selection function of a preferred embodiment of the present invention;

FIGS. 6-7 are flow diagrams illustrating a browse function of a set-top terminal of a preferred embodiment of the present invention;

FIG. 8 is layout diagram illustrating a browse banner of a preferred embodiment of the present invention;

FIGS. 9-13 are flow diagrams illustrating channel and general setting functions of a set-top terminal of a preferred embodiment of the present invention;

FIG. 14 is an illustrative screen display of a general setting menu of a set-top terminal of a preferred embodiment of the present invention;

FIG. 15 is a flow diagram illustrating a general setting function of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 16-17 are illustrative screen displays of the time mode of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIG. 18 is a flow diagram illustrating entry, navigation, and tuning within the time mode of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIG. 19 is a flow diagram illustrating switching modes within an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 20–21 are illustrative screen displays of a theme mode of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 22–23 are illustrative screen displays of a title mode of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 24–27 are flow diagrams illustrating the operation of an interactive program guide of a set-top terminal of a preferred embodiment of the present invention;

FIG. 28 is a flow diagram illustrating an Impulse Pay-Per-View function of a set-top terminal of a preferred embodiment of the present invention;

FIG. 29 is an illustrative screen display of an Impulse Pay-Per-View barker of an Impulse Pay-Per-View function of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 30–32 are flow diagrams illustrating the operation of an Impulse Pay-Per-View function of a set-top terminal of a preferred embodiment of the present invention;

FIGS. 33–34 are flow diagrams illustrating the operation of a Near-Video-On-Demand function of a set-top terminal of a preferred embodiment of the present invention; and

FIG. 35 is an illustrative screen display of a messaging function of a set-top terminal of a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

A cable television system 1 of a preferred embodiment of the present invention is shown in FIG. 1. Cable system 1 includes five primary components: a headend 2; at least one fiber transport 3; at least one distribution hub 4; at least one hybrid fiber coax plant 5; and a plurality of set-top terminals 6, typically located in the homes of subscribers. Headend 2 is the primary source of programs, services, and control of cable system 1. Programs, services, and control signals are delivered to subscribers' set-top terminals 6 from headend 2 by transmitting signals through fiber transport 3, distribution hub 4, and hybrid fiber coax plant 5. These transmissions can be in the form of broadcasts to all set-top terminals, narrowcasts to a group of set-top terminals, multicasts to a list of particular set-top terminals, or unicasts to a single set-top terminal. The present invention can be implemented as a one-way cable television system in which signals are only transmitted from headend 2 to set-top terminals 6, or alternatively, in a preferred embodiment, can be implemented as a two-way interactive cable television system. Subscribers interact with the programs and services provided by headend 2 by transmitting signals from set-top terminals 6 through hybrid fiber coax 5, distribution hub 4, and fiber transport 3 to headend 2.

To provide the programs, services, and control of cable system 1, headend 2 includes a plurality of digital satellite receivers 10, a broadcast cable gateway (BCG) 11, a plurality of analog satellite receivers 12, a plurality of integrated receiver decoders (IRD) 13, analog scrambling and modulation circuitry 20, an addressable controller (AC) 14, a plurality of application servers 15, a plurality of media servers 16, a digital switch or multiplexer 17, and an interactive cable gateway (ICG) 18. Although each of these headend 2 elements are described as single functions, each can be implemented as part of a single device, as a single device, or as a plurality of devices.

The programs and services generated by headend 2 are received from four primary sources: analog satellite transmissions from analog service providers, digital satellite transmissions from digital service providers, application programs and services on application servers 15, and media programs and services on media servers 16. Programs and services can also be received at headend 2 from other sources, such as, for example, analog off-air signals, digital off-air signals, and locally originated signals. Analog and digital satellite transmissions typically provide the traditional forms of television broadcast programs and information services. Application servers typically provide, for example, executable code and data for application specific services such as database services, network management services, transactional electronic commerce services, system administration console services, application specific services (such as stock ticker, sports ticker, weather, and interactive program guide data), resource management services, connection management services, subscriber care services, billing services, operation system services, and object management services. Media servers provide time-critical media assets, such as, for example, MPEG-2 encoded video and audio, MPEG-2 encoded still images, bit-mapped graphic images, PCM digital audio, three dimensional graphic objects, application programs, and application data files. Although specific examples of programs and services and the sources that provide them (such as analog and digital satellite transmissions, application servers, and media servers) are given herein, other programs and services, and programs and services from other sources, can be provided to cable system 1 without departing from the spirit and scope of the present invention.

To provide this multitude of programs and services to a subscriber's home on a single coaxial cable, these signals are preferably modulated onto a plurality of 6 MHZ frequency division multiplexed (FDM) channels in the RF spectrum from 5 MHZ through 860 MHZ. More specifically, the 6 MHZ FDM channels in the present invention can be used to carry analog channels with vertical blanking interval (VBI) signals, forward application transport (FAT) channels, forward data channels (FDC), and reverse data channels (RDC). In one embodiment of the present invention, analog channels are in the frequency range of 50 to 500 MHZ, FAT channels are in the frequency range of 500 to 750 MHZ, and FDCs and RDCs are in the frequency ranges of 5 to 40 MHZ and 70 to 130 MHZ, respectively. Although values for the bandwidth, upper limits, and lower limits of these channels are given herein, these values can be altered to suit the individual needs and capabilities of any system in which the present invention is implemented without departing from the spirit and scope of the present invention. For example, 1 MHZ FDM channels can be implemented wherein each of the analog channels, FAT channels, forward data channels, and reverse data channels use different sections of the RF spectrum.

Analog programs and services are received from satellite transmissions in the preferred embodiments of the present invention by analog satellite receivers 12, integrated receiver decoders 13, and analog scrambling and modulation circuitry 20. Analog satellite receivers 12 typically receive the satellite transmissions from the analog service providers in a modulated and scrambled NTSC format. Integrated receiver decoders 13 demodulate and descramble the satellite signals into NTSC signals, and then analog scrambling and modulation circuitry 20 scrambles (using the cable system's scrambling method, if desired) and modulates the NTSC signals onto an analog 6 MHZ FDM channel. The

11

FDM modulation frequencies and scrambling techniques used for the NTSC signals are preferably selected to maintain downward compatibility with analog set-top terminals that may be used with the present invention. The demodulation, descrambling, scrambling, and modulation functions performed by integrated receiver decoders 13 and analog scrambling and modulation circuitry 20 can alternatively be performed by other dedicated devices, such as, for example, satellite receivers, satellite decoders, NTSC scramblers, and NTSC modulators.

Digital services are received from satellite transmissions by digital satellite receivers 10. The signals received by digital satellite receivers 10 typically arrive in quadrature phase shift key (QPSK) modulated, encrypted MPEG-2 transport stream format. Once the satellite transmissions have been received by the digital satellite receivers, broadcast cable gateway (BCG) 11 converts the transmissions signals for transmission over the cable system's communication network under the control of addressable controller 14 broadcast cable gateway 11 demodulates, applies forward error correction (FEC), if desired, and decrypts the satellite transmission to recover an MPEG-2 transport stream. The MPEG-2 transport stream may then be manipulated by BCG 11 to remove unwanted programs from the stream to form an MPEG-2 payload. BCG 11 then encrypts the payload (if desired) and modulates it onto a forward application transport (FAT) 6 MHZ FDM channel. The modulation of FAT channels is preferably 64 or 256 quadrature amplitude modulation (QAM), which enables the channels to carry digital data at rates typically in the range of 27 to 38 Mbps, respectively. By using MPEG-2 payloads, the present invention provides an increase in the number of programs and services that can be transmitted on a 6 MHZ channel over that available with analog technology by digitally compressing and combining a plurality of programs and services into a single MPEG-2 payload.

Application and media programs and services are provided by application and media servers 15 and 16 under the control of addressable controller 14 through digital switch or multiplexer 17, interactive cable gateway 18, and data channel gateways 19 in distribution hubs 4. The programs and services provided by application and media servers 15 and 16 are preferably provided in MPEG-2 transport stream format. Addressable controller 14 may oversee the distribution of programs and services by servers 15 and 16 by processing requests for programs and services from set-top terminals 6, instructing the servers when, where, and how to deliver a requested program or service, and directing the programs and services through the digital switch or multiplexer to the interactive cable gateway and data channel gateways in the distribution hubs.

Digital switch or multiplexer 17 connects servers 15 and 16 to addressable controller 14, to interactive cable gateway 18, and to data channel gateways 19 in distribution hubs 4. Because the programs and services provided by application servers 15 typically do not require high bandwidth, these servers can be connected to digital switch or multiplexer 17 directly (as shown) or via intermediate networks. Media servers 16, however, do require a great deal of bandwidth and accordingly should be connected to digital switch or multiplexer 17 or interactive cable gateway 18 directly until intermediate networks with sufficient bandwidth become available. Furthermore, to achieve their high bandwidth requirement, media servers 16 should incorporate storage devices having interfaces with speeds of at least SCSI Fast and SCSI Wide interfaces, and preferably speeds of Ultra SCSI and fiber channel interfaces.

12

Interactive cable gateway (ICG) 18 processes the servers' signals so they can be transmitted over the cable system's communication network. Signals received at ICG 18, either through digital switch or multiplexer 17 or from servers 15 or 16 directly, are optionally encrypted, optionally subjected to forward error correction (FEC), and modulated onto a 6 MHZ FAT channel using 64 or 256 quadrature amplitude modulation (QAM).

The analog channels, forward application transport 10 channels, forward data channels, and reverse data channels are transmitted between the cable headend and the set-top terminals over the cable systems' communication network. As shown in FIG. 2, this network comprises at least one fiber transport 3, at least one distribution hub 4, and at least one hybrid fiber coax plant 5.

Each fiber transport 3 connects headend 2 to at least one distribution hub 4. Typically fiber transport 3 is physically configured as a ring of bundled fiber optic cables. In this configuration, six cables in the bundle of each fiber transport 3 are typically dedicated to each hub 4 on the ring, and each hub 4 is typically within twenty miles of headend 2. For those hubs 4 that are more than a limiting distance (e.g., more than 20 miles) from headend 2, an intermediate distribution hub 4 may be needed to retransmit the signals in fiber transport 3.

By selecting particular fiber optic cables within the bundle of fiber transports 3, the distribution hubs can be connected to headend 2 through adjacent hubs in a logical "ring" configuration, or directly to headend 2 in a logical "star" configuration. Alternatively, other logical configurations can be used. However, an advantage of the ring configuration is that no distribution hub 4 is cut off from headend 2 by a single break in fiber transport 3.

Hybrid fiber coax plants 5 connect distribution hubs 4 to set-top terminals 6. In a preferred embodiment, hybrid fiber coax plants 5 include a plurality of fiber optic cables 25, a plurality of nodes 26, and a plurality of coaxial cables 27. A plurality of radio frequency (RF) amplifiers (not shown) may also be required at various locations throughout coaxial cables 27 to compensate for losses that occur when the coaxial cable is split to connect each set top terminal. Nodes 26 convert the optical signals in fiber optic cables 25 generated by the distribution hub 4 into electrical signals for transmission on coaxial cables 27 to set-top terminals 6. Return signals from set-top terminals 6 on coaxial cables 27 are converted to optical signals by nodes 26 for transmission in fiber optic cable 27 to distribution hubs 4.

As shown in FIG. 1, each distribution hub 4 comprises a plurality of data channel gateways 19 that support the forward and reverse data channels between headend 2 and set-top terminals 6. In the preferred embodiment of the present invention, the signals in the forward and reverse data channels between headend 2 and data channel gateways 19 are Internet protocol datagrams. Between data channel gateways 19 and set-top terminals 6, these Internet protocol datagrams may be encrypted or decrypted, as desired, and QPSK modulated or demodulated. Accordingly, data channel gateways 19 can include routing, encryption, decryption, QPSK modulation, and QPSK demodulation functions.

One embodiment of set-top terminal 6 constructed in accordance with the present invention is shown in FIG. 3. Set-top terminal 6 includes the following: a central processing unit (CPU) 30, a memory management unit 31, memory 32 comprising NVRAM, DRAM, flash read only memory (ROM), and ROM, an MPEG-2 decompression unit 33, an A/D converter 34, an IP router 35, a security unit 36, a QAM

64/256 demodulator 37, an NTSC decoder 38, a QPSK demodulate unit 39, a QPSK modulate unit 40, an in-band tuner 41, an out-of-band tuner 42, an out-of-band transmitter 43, an NTSC encoder 44, an RF modulator 61, an RF output 45, an S-Video output 47, a baseband video output 48, a graphics subsystem 46, an audio subsystem 49, an AC-3 audio output 50, a baseband audio output 51, an I/O subsystem 52, a keypad 53, an LED display 54, an IR receiver 55, an IR transmitter 56, an accessories bus interface 57, and a 10-base-T interface 58.

Controlling the operation of set-top terminal 6 is central processing unit 30. Preferably CPU 30 is a processor that can support 32 bit arithmetic and logical operations, operate at speeds of at least 25 MIPS, and support a system of dynamically prioritizable hardware and software interrupts. An example of a suitable processor for CPU 30 is the SUN Micro-Systems micro-SPARC core. CPU 30 executes instructions stored in memory 32 under the control of an operating system such as the PowerTV Operating System by PowerTV, Inc., of Cupertino, Calif. CPU 30 accesses memory 32 through memory management unit (MMU) 31. MMU 31 provides memory protection for application processes and the kernel, and provides a flat address space for subscriber processes.

Memory 32 comprises non-volatile random access memory (NVRAM), dynamic random access memory (DRAM), flash read only memory (ROM), and read only memory (ROM). NVRAM is used primarily for the storage of subscriber settings and set-top terminal configuration settings, such as, for example, parental control codes, favorite channel line ups, set-top terminal setups, channel maps, authorization tables, and forward data channel address assignments. At least 2K bytes of NVRAM should be provided in memory 32. Dynamic RAM is used for most application and operating system storage requirements, such as, for example, the stack, heap, graphics, interactive program guide data, channel map, VCR codes, marketing data, and usage data, and functions such as MPEG-2 video decompression, AC-3 audio decoding, and video manipulation. At least 3M bytes of dynamic RAM should be provided in memory 32. Flash ROM is used primarily for the storage of resident application software, as well as patches to the operating system and application software which are downloaded to the set-top terminal from the headend after the set-top terminal has been deployed in the subscriber's home. At least 1M byte of flash ROM should be provided in memory 32. ROM is used primarily for the storage of the operating system. At least 1M byte of read only memory should be provided in memory 32. Although specific purposes for the NVRAM, DRAM, flash ROM, and ROM are illustrated herein, these memory elements can be used for purposes not listed and for purposes listed as corresponding to other elements without departing from the spirit and scope of the present invention.

Frequency division multiplexed (FDM) signals from headend 2 are initially received from hybrid fiber coax plant 5. In-band tuner 41 receives programs and services transmitted to the set-top terminal on analog channels and forward application transport channels. These programs and services include analog programs and services from analog satellite broadcasts, digital programs and services from digital satellite broadcasts, some digital programs and services from application servers, and digital programs and services from media servers. NTSC decoder 38 receives the analog programs and services from in-band tuner 41 and produces NTSC baseband signals. QAM 64/256 demodulator 37 receives the digital programs and services from in-band

tuner 41 and demodulates the signal into MPEG-2 payloads. Out-of-band tuner 42 receives only incoming IP datagram messages from headend 2 on the forward data channel. Messages transmitted from the headend to the set-top terminals in Internet protocol datagrams on the forward data channel include interactive program guide data messages as well as other data and control messages. Messages received by out-of-band tuner 42 are QPSK demodulated by QPSK demodulator 39 to reveal the IP datagrams. The analog NTSC baseband signals, the digital MPEG-2 payloads, and the digital IP datagrams are descrambled (if necessary), decrypted (if necessary), and screened by security unit 36. Additionally, security unit 36 provides encryption, key management, authentication, and secure transaction functions, and prevents downloading of viruses by authenticating trusted sources, vandalism of software, theft of services, falsified orders by using electronic signatures, tampering with the set-top terminal, and direct cloning or remanufacturing of the set-top terminal.

After descrambling, decryption, and screening by security unit 36, the baseband signals, MPEG-2 payloads, and IP datagrams are passed on to the analog-to-digital converter 34, MPEG-2 decompress unit 33, and IP router 35. As their names imply, analog-to-digital converter 34 converts the NTSC baseband signals to digital signals; MPEG-2 decompress unit 33 decompresses the MPEG-2 payloads; and IP router 35 routes the IP datagrams toward their ultimate destination.

Outgoing IP datagram messages are also processed by IP router 35. After routing the outgoing IP datagrams, security unit 36 screens and encrypts the IP datagrams (if necessary). The IP datagrams are then QPSK modulated by QPSK modulator 40 and transmitted to hybrid fiber coax plant 5 by out-of-band transmitter 43.

The video and audio outputs of set-top terminal 6 are generated by graphics subsystem 46, audio subsystem 49, NTSC encoder 44, and RF modulator 61. Graphic subsystem 46 produces graphic images and scales MPEG-2 and NTSC video. NTSC encoder 44 generates S-Video output 47 and baseband video output 48 from digitized MPEG-2 and NTSC video. Audio subsystem 49 produces the audio outputs for set-top terminal 6 including AC-3 audio output 50 and baseband audio output 51. RF modulator 61 generates NTSC RF output 45 necessary to drive a television without S-Video or baseband inputs from signals received from NTSC encoder 44 and audio subsystem 49.

I/O subsystem 52 controls input and output functions and the 10-base-T computer interface for set-top terminal 6. As shown in FIG. 3, I/O subsystem 52 receives inputs from keypad 53, I/R receiver 55, accessories bus 57, and 10-base-T interface 58. I/O subsystem 52 also produces outputs to LED display 54, I/R transmitter 56, accessories bus 57, and 10-base-T interface 58. Keypad 53 enables the subscriber to control set-top terminal 6 without remote control 59. LED display 54 provides a numeric display for channel or time indication, and provides a plurality of single LEDs to indicate statuses such as power on, message waiting, set-top output disabled, etc. I/R receiver 54 receives and digitizes input from remote control 59. I/R transmitter 56 controls a VCR 60 and sends updates to remote control 59. Accessories bus 57 connects to external equipment such as keyboards, joysticks, mouses, I/R transmitters, etc. The 10-base-T interface can be used to connect to Ethernet interfaces in equipment such as routers, personal computers, or home entertainment equipment.

FIGS. 4 through 35 illustrate the operation of preferred embodiments of the application software of set-top terminal

6 of the present invention. Referring to FIG. 4, the operation of the channel selection function of one embodiment of the present invention is shown. From a first channel display 100, the channel selection function changes channels in response to pressing a channel up/down key 102 on set-top terminal 6 or its remote control 59. This causes a second channel display 106 to be displayed. In the preferred embodiment of the channel selection function, a program information banner 114 is displayed indicating the current channel's channel number 116, the current channel's call sign 118, current time 120, the current program's name 123, running time 125, and elapsed time 127. Banner 114 may also include information regarding the program following the program currently being transmitted. Banner 114 is preferably displayed for a fixed period of time (e.g., 2 seconds) or until an information key 104 is depressed on set-top terminal 6 or its remote control 59. Pressing channel up/down key 102 again causes set-top terminal 6 to select the next channel in order. For example, as shown, pressing the up side of channel up/down key 102 causes the display to switch from channel 4 (KNBC) to channel 5 (HBO). Similar to the initial display of second display 106, the initial display of a third channel display 108 can include a program information banner 122.

Additionally, in the preferred embodiments of the present invention, pressing information key 104 from a first channel display 100 causes a program information banner 124 to be displayed on first channel display 100. Similar to program information banners 120 and 122, program information banner 124 can display the current channel's channel number, the current channel's call sign, the current time, the current program name, the program's running time, and the program's elapsed time. Like banner 114, banner 124 may also include information regarding the program following the program currently being transmitted. Pressing information key 104 again with program information banner 124 displayed preferably causes a more detailed program information banner 126 to be displayed on first channel display 100. Unlike banners 114, 122, and 124, more detailed program information banner 126 preferably does not display the running time and elapsed time but rather displays a brief description of the program's contents. As shown, program information banner 126 may omit the current program's name or, as in the preferred embodiments, may include the current program's name.

As an alternative to changing channels using channel up/down key 102 as shown in FIG. 4, channel selection can be accomplished by entering the number of a channel on a numeric keypad. Such a keypad is preferably on remote control 59 and can also be on set-top terminal 6. The channel number is entered on the numeric keypad one digit at a time from left to right, optionally preceded by zeros if the number of digits in the channel number is less than the number of digits required for the channel selection function. For example, in a set-top terminal with three-digit selection, a subscriber enters the channel number "125" by pressing the one-key, followed by the two-key, and then by the five-key. To enter the number "50" on a three-digit selection set-top terminal 6, the subscriber enters the number zero, then five, then zero, or simply enters a five followed by a zero. In the latter case, set-top terminal 6 automatically adds the leading zero to the channel number and selects the new channel accordingly.

In the preferred embodiments, the channel selection function of the present invention includes a plurality of channel cross-reference tables as shown in FIG. 5. These tables cross reference set-top terminal channels with a variety of television services, which can include various types of video and

audio programming and online services. Transparent to subscribers, selection of a channel transfers control to a specific application program that, along with one or more appropriate parameters obtained from the cross-reference tables, activates (i.e., displays on the selected channel) the television service associated with that selected channel. The channel selection function advantageously enables set-top terminal 6 to process data from sources other than just traditional analog video broadcast sources. These other sources can include, for example, MPEG video, VBI, IP, and ROM.

Referring to FIG. 5, channel table 101 associates channels of set-top terminal 6 with a plurality of television services listed in service table 103. When a subscriber selects a channel, that channel is first identified in channel table 101 where a pointer associates the channel with a particular service in service table 103. For example, channel 5 is associated with service 4, channel 7 is associated with service 6, and channel 14 is associated with service 14.

Service table 103 preferably indicates the type of service provided. For example, as shown in column 111, services 1-5 are video services, service 6 is a split service (described below), services 12 and 13 are music services, and service 14 is an NVOD service. Optionally, a channel does not have to be associated with a television service, in which case it is associated with "null" service 0 (e.g., channels 8 and 9 are associated with service 0). Other service types, such as, for example, a home shopping service, a still image library service, an online database service, a World Wide Web browsing service, or an E-Mail service, can be added to service table 103 and are represented in service table 103 by "other" service 16.

Service table 103 preferably provides descriptive information for each television service listed. Represented by column 125, this information may include, for example, the service's logo, programming schedule, and program content, and can be used as a source for the program information banners described previously or the browse information banners and interactive program guide described in more detail further below.

Service table 103 further preferably provides parameter references as shown in column 123 for identifying sources of listed television services. The parameter references point to parameter tables, such as, for example, video parameter table 105, split parameter table 107, music parameter table 109, NVOD parameter table 127, VOD parameter table 129, and "other" parameter table 131.

Video parameter table 105 provides application parameters needed to activate video sources 1-9. The content of video sources 1-9 may include, for example, recently released movies, classic movies, science fiction programming, or weather information. Application software parameters are used by set-top terminal 6 (in particular, CPU 30) when executing application software, and may simply include the frequency of a particular source's signals or other more complex variables.

Split parameter table 107 allows a channel to be associated with two or more services, each during different time periods. These services can be of different types and from different sources. For example, if a subscriber selects channel 7, set-top terminal 6 determines from channel table 101 that channel 7 is associated with service 6. From service table 103, set-top terminal 6 determines that the source of service 6 is a split service governed by split parameter table 107. From split parameter table 107, set-top terminal 6 determines that channel 7 is associated with service 10

during time period one (time1) and service 11 during time period two (time2). Set-top terminal 6 then refers to video parameter table 105 to determine the sources and parameters for activating services 10 and 11. Thus, selecting channel 7 will cause set-top terminal 6 to activate source 8 during time period one and source 9 during time period two.

The other parameter tables function similarly to video parameter table 105. Music parameter table 109 identifies sources of music and provides the appropriate parameters for activating these sources. NVOD parameter table 127 provides application parameters for activating a Near-Video-On-Demand service and, similarly, VOD parameter table 129 provides application parameters for activating a Video-On-Demand service. Other Parameter Table 131 is representative of other television service sources and application parameters that can be provided by a cable system of the present invention.

In sum, the cross reference tables of the channel selection function enable set-top terminal 6 to execute software and activate a variety of television services. When a subscriber selects a channel, set-top terminal 6 identifies the type of service associated with the selected channel from channel table 101 and service table 103, and then executes the appropriate program (or special routine within the running program that allows channel selection) to tune in the frequency of the service's source by referring to the appropriate parameter table, descrambling the signal if necessary, and displaying the source's contents on the selected channel. Advantageously, set-top terminal 6 can respond to other types of services that require more interaction. For example, a request to view a channel incorporating a World Wide Web browser results in set-top terminal 6 executing either a resident copy of a Web browser or a downloaded copy from the headend, requesting log-in information from the subscriber, and establishing a browsing session with the headend. Thus the types of services that can be provided to subscribers are not limited by set-top terminal 6. Preferably, new types of services can be added to the cable system's offerings by downloading a new service type module to set-top terminal 6. The cross-reference tables (i.e., channel, service, and parameter tables) are accordingly updated and the new module can then be executed whenever a subscriber selects a channel corresponding to that service.

Furthermore, by configuring set-top terminal channel settings based on entries in service table 103 rather than on entries in channel table 101, changes in the cable channel lineup over which television services are transmitted to set-top terminal 6 do not invalidate a subscriber's set-top terminal channel settings. In other words, the subscriber's mapping of set-top terminal channels to television services is maintained even if the cable service provider reassigns the cable channels over which those services are transmitted. Preferably, when such a reassignment occurs, an updated channel-to-service mapping corresponding to the reassignment is downloaded to set-top terminal 6 to maintain the existing association of set-top terminal channels to television services. Thus, for example, once parents configure channel settings to block particular services deemed inappropriate for their children, a reassignment of cable channels over which those services are transmitted will not affect those services' blocked status. Similarly, other channel settings, such as a subscriber's favorite channel line-up, will also not be affected if such cable channel reassessments occur.

To prevent channel settings from becoming invalid during the lifetime of a set-top terminal, television services listed in service table 103 of a preferred embodiment of the present

invention are typically not deleted or replaced. Instead, a new service is assigned to reserved space or space which is dynamically allocated within service table 103.

The manner in which requests for services are made by different applications within set-top terminal 6 are simplified in a preferred embodiment of the present invention by incorporating a uniform resource locator (URL), similar to that on the Internet, to uniformly identify services requested. Services are identified by a URL that incorporates information regarding the format, physical location, logical location, and identity of the service requested (e.g., format://physical/logical/identity). For example, if a service is requested that resides on a server at the headend, the URL identifies the format (e.g., the headend's format), the particular server at the headend, the directory on that server, and the file in that directory. Alternatively, if a service is requested that resides in set-top terminal 6, the URL identifies the format (e.g., code segment format), the physical location (i.e., set-top terminal 6), the particular block of memory, and the memory address of the requested service.

FIG. 6 illustrates the "Browse" mode of the present invention. The browse mode is entered by pressing the up, down, left, or right arrow keys whenever a program information banner or more detailed program information banner is being displayed. For example, from a television display 110 incorporating either a program information banner 124 or a more detailed program information banner 126, pressing up or down arrow keys 128 causes a browse information banner 132 to be displayed. Browse information banner 132 displays information for programs other than that currently being displayed on display 110. As shown, a program entitled "Comedy: D. Miller" is being displayed on display 110 (see program information banner 124). However, browse information banner 132 reflects information for a program entitled "CBS Sports." The subscriber can therefore determine what other programs are available for viewing while still observing the currently selected program. By repeatedly pressing up or down arrow keys 128, information regarding other concurrently transmitted television programs can also be displayed on browse information banner 132. Pressing information key 104 whenever a browse information banner 132 is displayed causes banner 132 to be replaced by a more detailed browse information banner 142 displaying a brief description of the browse program rather than the browse running time and elapsed time. As with the program information banner 126, browse information banner 142 may omit the browse program's name (as shown) or, as in the preferred embodiments, may include the browse program's name.

The browse mode of set-top terminal 6 can be exited by pressing channel up/down key 102, by pressing select key 136, by pressing information key 104 whenever more detailed browse information banner 142 is displayed, or by waiting a fixed period of time (e.g., 20 seconds) without pressing any remote control 59 or set-top terminal 6 key. More particularly, pressing channel up/down key 102 with a displayed browse information banner 132 causes the following: the banner is removed from the display, the channel tuner selects and displays the next channel following the previously displayed channel (in this case channel 4 follows the previously displayed channel 3 since the up side of channel up/down key 102 was pressed), and a program information banner 133 is displayed for the new channel as shown in channel display 106. Alternatively, pressing select key 136 with browse information banner 132 displayed causes set-top terminal 6 to tune in and display browse channel 138 and to briefly display a program information banner 140.

The browse information banner can also be used to display information for programs that were or will be transmitted. For example, as shown in FIG. 7, browse information banner 152 can be used to display information for a program airing in twenty minutes from the current time. This can be done, for example, as follows: from a program information banner 124 displayed within a television display 110, the browse mode of set-top terminal 6 is entered by pressing up arrow key 128. With the browse mode entered, a browse information banner 148 displays information for a browse channel (i.e., channel 4, KNBC) during a browse period which straddles the current time (i.e., 8:10 p.m.). By pressing right arrow key 128, the browse period changes to the period for the next program on the browse channel. Alternatively, the subscriber can press left arrow key 128 to change the browse period to the previous program on the browse channel. In a similar fashion, by repeatedly pressing up, down, left, and right arrow keys 128, the subscriber can view information for programs on other channels and at different times.

As described in connection with FIG. 6, once the subscriber has viewed browse information banner 152, more detailed information can be obtained or the subscriber can exit the browse mode of set-top terminal 6. For example, by pressing information key 104 with the browse information banner 152 displayed, the subscriber causes browse information banner 152 to be replaced by a more detailed browse information banner 154. Banner 154 may replace the program name, running time, and elapsed time of banner 152 with a brief description of the browse program's contents. Alternatively, the browse mode may be exited by pressing channel up/down key 102 to view a new channel display 158 or by not pressing any keys on remote control 59 or terminal 6 for a fixed period of time (e.g., 20 seconds).

Although the embodiment of the browse banner shown in FIGS. 6 and 7 is activated from the program information banner by pressing the up or down arrow keys, the browse banner of the present invention can also be activated by pressing the left or right arrow keys from the program information banner.

FIG. 8 provides a more detailed illustration of an embodiment of the browse information banner of the present invention. As shown, browse information banner 160 can display the browse channel's channel number 160, call sign 162, logo 164, a favorite channel icon 166, a blocked channel icon 168, current time 170, the browse program's name 172, running time 174, elapsed time 176, and icons to indicate whether the browse program is closed-captioned 178, has a second audio program 180, is in stereo 182, and is designated to be recorded 184.

As shown in FIG. 9, a channel settings menu 190 allows the subscriber of set-top terminal 6 to change the favorite, blocked, and record status for each channel. The subscriber enables channel settings menu 190 by pressing a settings key 188 on set-top terminal 6 or its remote control 59 from any television display 186. As illustrated, channel settings menu 190 may be incorporated into the previously viewed television display 186 while leaving the television audio unaffected. Within channel settings menu 190, settings may be provided which allow the subscriber to add the current channel (i.e., KCBS) to the favorite channel list (setting 200), block the current channel (setting 202), and record the current channel (setting 204). To select any of settings 200, 202, or 204, the subscriber highlights one of the settings by positioning the setting within cursors 198 and 216 by pressing up or down arrow keys 128. In the preferred embodiments of the present invention, cursors 198 and 216

remain in a fixed vertical position within menu 190 as the subscriber presses up and down arrow keys 128 and the list of settings scrolls such that the settings list comprising settings 200, 202, and 204 moves in the opposite direction of the key pressed. That is, when the subscriber presses up arrow key 128, the list moves down and the cursor remains fixed, thereby giving the net effect of the cursor moving up within the list. Set-top terminal 6 indicates that the subscriber may press up and down arrow keys 128 to highlight different settings using cursors 198 and 216 by providing up and down arrow indicators 194 and 196. With cursors 198 and 216 on the desired setting, the subscriber may then enable or disable the highlighted setting by pressing left and right arrow keys 128. Similarly to up and down arrow indicators 194 and 196, menu 190 provides left and right arrow indicators 206 and 208 to indicate that the subscriber may press left and right arrow keys 128 to enable or disable the highlighted setting. Setting indicators 210, 212, and 214 will shift position to beneath either the "YES" column 218 or "NO" column 220 to indicate to the subscriber whether each function is enabled or disabled, respectively.

A general settings menu 224, as shown in FIG. 10, is also provided in a preferred embodiment of the present invention. Menu 224 enables a subscriber to make further settings adjustments to set-top terminal 6. The subscriber enters general settings menu 224 by pressing settings key 188 from channel setting menu 222. As with the channel settings menu 222, general settings menu 224 may be incorporated into the previously displayed television display 250 without affecting the television audio. Within general settings menu 224, the subscriber may control settings such as blocked channels 228, favorite channels 230, VCR timers 232, IPPV purchases 234, sleep timers 236, and wake timers 238. Other settings available in general settings menu 224, but not illustrated, can include, for example, reminder timers, view all timers, block times, setup blocking PIN, setup purchase PIN, set power-on channel, enable second audio program (SAP), set audio output level, set AC outlet function, set VCR type, set clock options, control VCR on/off, and enable watch and record. Similarly to channel settings menu 190 (FIG. 9), a subscriber selects the desired setting by positioning the desired setting 228, 230, 232, 234, 236, or 238 within a cursor 226 using up and down arrow keys 128, as is indicated by up and down arrow indicators 240 and 242. As with channel settings menu 190, in the preferred embodiments of the present invention, cursor 226 remains in fixed vertical position within general settings menu 224 and the list of settings scroll in a direction opposite to the direction of the up and down arrow keys depressed.

Once the desired setting has been highlighted by cursor 226, the subscriber may then view or modify contents of the setting by pressing right arrow key 128 (as is indicated by right arrow indicator 246) or select key 136 to move cursor 226 to right half 248 of general settings menu 224. In cases where a setting has not been previously set or the contents of the setting have been erased, an indication such as "(New . . .)" will be displayed in right half 248 of menu 224 to indicate to the subscriber that the setting is empty. When the subscriber has completed using general settings menu 224, the subscriber may exit the menu by pressing settings key 188 to return to previous television display 250. Alternatively to exiting the general settings menu 224, the subscriber may also select another general setting by returning to the left half of menu 224 by pressing left arrow key 128, as indicated by left arrow indicator 244.

FIGS. 11 through 15 illustrate the VCR timers, IPPV purchases, all timers, and favorite channel settings of the

general settings menu. Referring to FIG. 11, one embodiment of the VCR timers setting is shown. Selecting the VCR timers setting by pressing right arrow key 128 or select key 136 with VCR timers setting 256 highlighted in general settings menu 254 causes cursor 255 to be removed from the display and a new cursor 257 to be displayed in the left-most column of right half 248 of the general settings menu as shown in menu 258. In cases in which the VCR timers setting is selected when contents for the setting do not exist, set-top terminal 6 will determine default contents for the setting. The contents may be either the current program being viewed prior to entering the general settings menu, or may be the next program to be aired if within a fixed period of time (e.g., 10 minutes) of the start time of the next program. Pressing either up or down arrow keys 128 causes each parameter to cycle to the next higher or lower value for that parameter. As shown in menu 260, pressing up arrow key 128 causes the date to change from "Mo 23" to "Tu 24." Pressing right arrow key 128 or select key 136 causes cursor 257 to be removed from the display and a new cursor (e.g., cursor 259) to be displayed in the next, rightward, parameter as shown in menu 262. Alternatively, pressing left arrow key 128 causes cursor 257 to be removed from the display and a new cursor to be displayed in the previous parameter. By using arrow keys 128 in this fashion, the subscriber is able to select the date, channel, start time, and stop time for the VCR timers setting.

Once the subscriber has modified the contents of the VCR timer setting, the subscriber may accept or cancel the modifications as indicated by "A" and "C" indicators 261 and 263. To accept the modified setting, the subscriber presses the "A" application definable key 252. If the subscriber accepts the settings, a cursor will be displayed in list of settings 249 and the modified setting will be displayed as shown in menu 264. To cancel the modified setting, the subscriber presses "C" application definable key 252. Alternatively, if left arrow key 128 is pressed when a cursor is displayed in the left-most column in right half 248 of the general settings menu (as shown in menu 258), any changes to the setting will be canceled. Once canceled, a cursor will be displayed in list of settings 249 and the prior contents of the setting will be displayed.

FIG. 12 illustrates the conflict checking feature of the present invention. Upon pressing select key 136, settings key 188, or channel up/down key 102 after modifying a timer setting's contents from within general settings menu 268, set-top terminal 6 verifies that there are no conflicts created by the modified setting. Conflicts can arise, for example, when there are overlapping timers, unusual settings (such as VCR record timers which exceed typical tape length), record timers for unpurchased Impulse Pay-Per-View (IPPV) events, attempts to set up more than a limited number of VCR timers (e.g., eight), and attempts to purchase more than a limited number of IPPV events (e.g., eight). For example, upon pressing select key 136 from general settings menu 268 when attempting to record an IPPV event, set-top terminal 6 displays an interactive warning window 270 alerting the subscriber that the IPPV event sought to be recorded has not been purchased. Interactive warning window 270 then allows the subscriber to press "B" or "C" application definable keys 252 to either buy the IPPV event or cancel the warning. Pressing select key 136 from general settings menu 268 for non-IPPV events causes another interactive warning window 272 to be displayed when there are conflicting timers. For example, interactive warning window 272 is displayed when there is an attempt to record two different programs at overlapping times. As illustrated,

the subscriber has the choice of selecting one of "A," "B," and "C" application definable keys 252 in response to this warning in the preferred embodiment. Pressing "A" key 252 causes set-top terminal 6 to keep both settings and apply logic to resolve the conflict as shown in menu 274 ("VCR Timer 1" referring to the first setting and "VCR Timer 2" referring to the second). This can be accomplished, for example, in cases where two recording timers partially overlap by recording up until the start time of the second program and dropping the end of the first program. Pressing "B" key 252 in response to interactive warning window 272 causes the conflict to be resolved by a new setting that overwrites the old setting as shown in menu 276. Pressing "C" key 252 in response to interactive warning window 272 causes the old setting to be retained in general settings menu 278 and cursor 226 to remain displayed on right side 248 of the general settings menu to indicate to the subscriber that the most recent setting has not been accepted.

When the subscriber exits general settings menu 268 by pressing settings key 188 or channel up/down key 102 while leaving behind a conflicting setting, a non-interactive warning window 280 is displayed for a brief period of time (e.g., five seconds) to inform the subscriber of the conflict. To resolve the conflict, the subscriber must press settings key 188 to reenter the general settings menu. Upon reentering the general settings menu, the subscriber is prompted with interactive warning window 272 so the conflict can be resolved using the procedure previously described.

FIG. 13 illustrates the Impulse Pay-Per-View (IPPV) purchases setting of the general settings menu. As shown in general settings menu 284, whenever IPPV Purchases setting 286 is highlighted, a summary indicator 288 is displayed in right half 248 of the general settings menu. Indicator 288 indicates the number of past and pending IPPV purchases. Pressing right arrow key 128 or select key 136 causes summary indicator 288 to be replaced by list 290 of past and pending purchases as shown in general settings menu 292. In the preferred embodiments of the present invention, a pending purchase can be removed from list 290 by pressing stop key 282 with a particular purchase highlighted. For example, with "%18 The Fugitive" highlighted in menu 292, pressing stop key 282 causes "%18 The Fugitive" to be removed from subsequent list 296 in subsequent menu 294. As with highlighting different settings 249 in the general settings menu, the IPPV purchases are highlighted by positioning the IPPV purchase within cursor 255 using up and down arrow keys 128. Like the cursor in the general settings menu, cursor 255 is preferably fixed in the vertical position.

When done reviewing list 290 of past and pending IPPV purchases, the subscriber may press the "A" application definable key 252 to exit. In response, the present invention removes the list from right side 248 of the general settings menu, replaces the list with an updated summary indicator 300, and highlights IPPV Purchases setting 286. In an alternative embodiment of the present invention (not shown), the subscriber may also press "C" application definable key 252 to cancel any IPPV cancellations that were made by highlighting a pending IPPV event and pressing stop key 282.

FIG. 14 illustrates an embodiment of the all timers setting of the general settings menu. As shown, selecting all timers setting 323 within general settings menu 322 causes list 325 of type 324, day 326, date 330, time 332, channel number 334, and channel call sign 336 for each active timer in set-top terminal 6 to be displayed. As with IPPV purchases (see the description accompanying FIG. 13), pressing stop

key 282 with any timer highlighted causes that timer to be canceled and accordingly removed from all timers list 325. As indicated by up and down arrow indicators 327 and 329, up and down arrow keys 128 are used to highlight timers within list 325 by positioning a timer within cursor 255. As with the other settings, cursor 255 is preferably fixed in the vertical position. Once the subscriber has completed reviewing and modifying all timers list 325, the subscriber may accept the changes by pressing "A" application definable key 252 as indicated by prompt 328. In an alternative embodiment of the present invention (not shown) the subscriber may also press "C" application definable key 252 to cancel any timer cancellations made by highlighting a timer and pressing stop key 282.

The favorite channels setting of the general settings menu is shown in FIG. 15. By selecting favorite channels setting 304 of general settings list 249 the subscriber causes listing 306 of favorite channels to be displayed on right side 248 of general settings menu 302. Pressing "C" application definable key 252 causes list 306 to be cleared as represented by list 306 in menu 308. Pressing right arrow key 128 or select key 136, however, brings up an available channel list 310 as shown in menu 312. List 310 shows all of the available channels along with check marks 311 next to the channels which are included in favorite channel listing 306. Pressing right arrow key 128 or select key 136 while a channel within available channel list 310 is highlighted causes the highlighted channel to be toggled to and from favorite channel list 306 as shown in menu 314. That is, if the channel is included in list 306, and therefore checked in list 310, pressing right arrow key 128 or select key 136 causes the channel to be removed from favorite channel list 306 and unchecked in list 310. On the other hand, with a channel not listed in favorite channel list 306, and therefore not checked in available channel list 310, pressing right arrow key 128 or select key 136 causes the channel to be added to favorite channel list 306 and checked in available channel list 310. As with other settings within the general settings menu, channels within list of available channels 310 are highlighted by positioning the channel within cursor 255 by pressing up and down arrow keys 128. General settings menu 316 illustrates a preferred embodiment of the present invention in which cursor 255 remains in fixed vertical position within list 310. As shown, available channel list 310 was scrolled from that shown in menu 312 to highlight "28 DISC." Once highlighted, right arrow key 128 or select key 136 was pressed to add "28 DISC" to favorite channel list 306.

When the subscriber has finished viewing and editing favorite channel list 306, the subscriber may exit the favorite channels setting by pressing "A" or "C" application definable keys 252. Pressing "A" key 252 causes the additions and deletions to be accepted by set-top terminal 6 as shown in general settings menu 318. Pressing "C" key 252, however, causes all changes to be discarded and favorite channel list 306 to remain as it was prior to modification as illustrated in general settings menu 320.

FIG. 16 illustrates the time mode of interactive program guide (IPG) 338 of the preferred embodiments of the present invention. As shown, guide 338 includes program viewing window 340, current time and channel indicator 342, highlighted channel banner 344, highlighted program summary 346, guide date and time bar 348, channel list 350, program grid 366, and key indicators 352, 354, 356, 358, 360, 362, and 364. As shown, region 339 around indicator 360 is highlighted as compared with regions 341 and 343 around indicators 362 and 364, respectively, to indicate that the

interactive program guide is in the time mode rather than alternative theme or title modes. Program viewing window 340 displays a reduced size display of the normal television display so that the program being viewed prior to entering the program guide may continue to be viewed while in the guide. Incorporated into program viewing window 340 is a current time and channel indicator 342. Indicator 342 may be transparent or opaque, and displays the time and channel number currently being displayed. Highlighted channel banner 344 may indicate logo 368, call sign 370, and number 372 for the channel highlighted in channel list 350 by channel shadow 392. Highlighted program summary 346 may list program name 374, running time 376, brief description 378, and icons 380 indicating applicable characteristics of the program such as closed captioning, second audio program (SAP), and stereo for the program highlighted in program grid 366 by program cursor 394. Guide date and time bar 348 lists in a preferably horizontal arrangement, from left to right, day 382, date 384, and times 386 of programs listed in program grid 366. Times 386 are typically incremented in half hour steps, and span one and a half hours, although other time increments and spans can be used. Channel list 350 is positioned beneath day 382 and date 384 indicators of guide date and time bar 348, and lists call signs 388 and channel numbers 390 for each of the channels available to the subscriber. As shown, only a portion of channel list 350 is usually displayed as indicated by up and down arrow indicators 352 and 354.

Program grid 366 includes a plurality of rows, each including at least one program cell 396. The number of rows in grid 366 matches the number of displayed channels in channel list 350, and each row in grid 366 is horizontally aligned with the displayed channels in channel list 350 so that the displayed channels act as labels for each row. The size of each cell 396 in grid 366 is a function of the running time of the program identified in that cell. For example, the cell entitled "Encounters" in grid 366 is one half hour long to indicate that the program "Encounters" is one half hour long. Similarly, the cell entitled "Money Line" in grid 366 is one hour long to indicate that the program "Money Line" is one hour long. The start time of each program identified in a respective cell can be determined by referring to the time indicated in date and time bar 348 directly above the leftmost end of each cell. For example, the program entitled "Money Line" begins at 4:30 p.m. as indicated by the time indicator "4:30 p.m." positioned directly above the leftmost end of the cell identifying "Money Line."

The subscriber of interactive program guide 338 navigates the program listings of grid 366 to highlight a desired program cell 396 with cursor 394 by pressing up, down, left, and right arrow keys (not shown) as indicated by up, down, left, and right arrow indicators 352, 354, 356, and 358. In the preferred embodiments, cursor 394 is always shadowed in channel list 350 by channel shadow 392 and in date and time bar 348 by time shadow 393. In these embodiments, channel shadow 392 always remains horizontally aligned with cursor 394 to indicate the channel on which the program highlighted by cursor 394 can be found. Similarly, in these embodiments, time shadow 393 always remains vertically aligned with cursor 394 to show the beginning of the time frame highlighted by cursor 394. For example, "KCBS 2" in channel list 350 and "4:00 p.m." in date and time bar 348 are shadowed by channel shadow 392 and time shadow 393, respectively, to indicate that "CBS Sports . . ." is on channel "KCBS 2" at "4:00 p.m."

In the preferred embodiment of the present invention, cursor 394 does not move within grid 366 of the interactive

program guide. Program cells 396 of grid 366, call signs 388 and channel numbers 390 of channel list 350, and times 386 of date and time bar 348 scroll instead. For example, as a subscriber presses up and down keys 128 (on remote control 59 or keypad 53 on set-top terminal 6), call signs 388 and channel numbers 390 in channel list 350 and program cells 396 in grid 366 scroll down and up, respectively. As the subscriber presses left and right arrow keys 128, times 386 in date and time bar 348 and program cells 396 in grid 366 scroll right and left, respectively. In the vertical directions, call signs 388, channel numbers 390, and cells 396 scroll one row for each depression of up or down arrow key 128. In the horizontal direction, times 386 and cells 396 scroll one time increment (e.g., one half hour as illustrated) for each depression of the left or right arrow key 128. Alternatively, times 386 and cells 396 can horizontally scroll to the next program cell 396 immediately following the currently highlighted program cell 396 when the subscriber presses right arrow key 128, and scroll to the previous program cell 396 immediately preceding the currently highlighted program cell 396 when the subscriber presses left arrow key 128. After the cells have scrolled up or down, or left or right, the stationary cursor 394 expands or contracts to highlight (preferably entirely) the leftmost program cell, and only the leftmost program cell, that has moved under the cursor's stationary position. Thus, the stationary cursor reacts in the same manner (to highlight the underlying cell) irrespective of the direction of movement of the underlying program grid 366.

As shown in FIG. 16, in a preferred embodiment of the present invention, channel list 350 rolls over when either the beginning or end of the list is reached. For example, as a subscriber scrolls list 350 upward, thereby giving the appearance of the channel shadow moving downward with respect to the list, the subscriber eventually reaches the end of the list of available channels. Rather than simply preventing the subscriber from scrolling list 350 any further when at the end of the list, set-top terminal 6 displays the beginning of the list following the end of the list and allows the channel shadow to move to the top of the list. Channel list 350 thus appears to be a circular list of channel numbers. Similarly, when the subscriber scrolls list 350 downward, thereby giving the appearance of the channel shadow moving upward with respect to the list, the bottom of list 350 will appear as the subscriber scrolls past the beginning of list 350. This feature of list 350 may also be applied to other lists within the present invention, including lists of settings, IPG guide data (in grid format), etc. Alternatively, the present invention can incorporate lists that do not roll over. In those cases, the subscriber cannot continue scrolling the channel list in the same direction once the top or bottom of the channel list has been reached.

As described in connection with FIG. 5, the present invention makes special provisions for channels which are split in time between two or more sources. As shown in FIG. 17, channel "147" within interactive program guide display 361 is split between "BRAV" 363 and "LIFE" 365. As illustrated, channel "147" switches from "BRAV" to "LIFE" at 5:00 p.m. Similarly, other splitting arrangements can be configured. For example, channel "147" (or any other channel number) can be used for three different daily sources, such as "BRAV" from 12:00 a.m. to 7:59 a.m., "LIFE" from 8:00 a.m. to 3:59 p.m., and "QVC" from 4:00 p.m. to 11:59 p.m. In such an arrangement, channel 147 can be presented in program grid 366 in at least two manners. First, each of the sources, "LIFE," "BRAV," and "QVC," can be assigned a row in grid 366 at all times during the day regardless of

whether the source is "ON AIR" during the time window displayed in the guide. Second, only those sources that are at least partially "ON AIR" during the time window displayed in the guide are allocated a line in grid 366. In this second approach, for example, displaying programs with times ranging from 3:00 p.m. to 4:30 p.m. shows a split at 4:00 p.m. with only two lines of the program guide allocated to channel 147.

FIG. 18 further illustrates the navigation features of the interactive program guide of the preferred embodiments of the present invention. Pressing guide key 398 from any television display 396 causes set-top terminal 6 to enter the time mode of interactive program guide 400. As shown, pressing right arrow key 128 causes the contents of cell 404 to scroll to cell 406 as illustrated in IPG 402. Similarly, the contents of all other cells scroll from their current position to the cell immediately to their left. Likewise, pressing left arrow key 128 causes the contents of the cells to scroll to the right. Thus the cell contents scroll in time, causing the cursor to highlight either the contents of an earlier or later cell under the action of left and right arrow keys 128, respectively. Similarly, pressing either up or down arrow keys 128 causes the cell contents to scroll vertically either down (with the contents of cell 407 moving to the position of cell 406) or up (with the contents of cell 409 moving to the position of cell 406), respectively, as shown in IPG 408. As the cell contents of grid 366 scroll up and down, the contents of channel list 350 also simultaneously scroll in the same direction.

After scrolling the contents of grid 366 to highlight a program other than the one currently being displayed, pressing select key 136 causes the interactive program guide to be removed from the display and the channel selection function to select the new program as illustrated by display 410. As shown, a program information banner 412 may be incorporated into display 410 for a fixed period of time (e.g., two seconds) to indicate to the subscriber that the selected program is being displayed. In cases where the subscriber does not wish to switch to a new program, pressing guide key 398 with the interactive program guide displayed causes the display to revert back to original television display 396.

FIG. 19 illustrates switching between different modes of the interactive program guide. From time mode display 414 of the guide, pressing "B" application definable key 252 causes theme mode display 416 of the guide to be presented. As illustrated, region 341 is highlighted to indicate the theme mode. Pressing "C" application definable key 252 from time mode display 414 causes title mode display 418 of the guide to be displayed. Similar to the theme mode, region 343 is highlighted to indicate the title mode. From either the theme mode or title mode, pressing "A" application definable key 252 causes the display to switch to time mode display 414. From the theme mode, pressing "C" application definable key 252 causes title mode display 418 to be displayed. From title mode display 418, pressing "B" application definable key 252 causes theme mode display 416 to be displayed. Accordingly, pressing "A" key 252 from any IPG display causes time mode display 414 to be displayed, pressing "B" key 252 from any IPG display causes theme mode display 416 to be displayed, and pressing "C" key 252 from any IPG display causes title mode display 418 to be displayed.

The theme mode display of the interactive program guide is further illustrated in FIG. 20. As shown, date and time bar 348, channel list 350, and program grid 366 of the title mode display (FIG. 16) are replaced by theme and programs bar 422, theme list 424, and program list 432 in

theme mode display 420. Similarly to channel listing 350, all available themes will not be displayed simultaneously when the length of themes listing 424 is greater than the available space in theme mode display 420. Up and down arrow indicators 426 and 428 are provided to indicate to the subscriber that list 424 may be scrolled by pressing up or down arrow keys (not shown). Using up and down arrow keys, the subscriber can scroll list 424 to highlight a desired theme with cursor 430. A right arrow indicator 434 is also provided to indicate to the subscriber that a highlighted theme must be selected by pressing right arrow key (not shown) or select key (not shown) to scroll through program list 432. As shown, when the subscriber enters theme mode display 420, the default theme and highlighted program may correspond to the program being viewed in program viewing window 340 or, alternatively, a highlighted program in a prior mode display of the interactive program guide. For example, entering the interactive program guide while watching "CBS Sports Special" and then selecting the theme mode will cause the theme "Sports" to be highlighted with "CBS Sports Special" centered in program list 432 next to right arrow indicator 434.

Once the subscriber has highlighted and selected a theme from theme list 424, set-top terminal 6 replaces theme list 424 with a selected theme indicator 436 as illustrated in FIG. 21. Up and down arrow indicators 437 and 439 are also provided to indicate that the subscriber may scroll through and highlight with cursor 440 a program within program list 432 by pressing up and down arrow keys 128. As with other lists in the present invention, cursor 440 is preferably stationary within the IPG display and list 432 scrolls to make the cursor appear to move with respect to list 432.

In some embodiments of the present invention, by scrolling through program list 432 the subscriber can see not only those programs within the selected theme, but also programs in other themes. This is facilitated by program list 432 comprising all programs for which data is available and by program list 432 being sorted primarily by program theme. In addition to being primarily sorted by theme, programs in program list 432 may also be secondarily sorted by time and title (as shown) or by any other set of program characteristics. When a subscriber selects a particular theme, set-top terminal 6 displays that portion of program list 432 in which the programs of the selected theme are positioned. The subscriber may then scroll through not only that portion of the list containing the programs of the selected theme but also programs in other theme areas.

By highlighting a desired program in program list 432, information for that program may be displayed to the subscriber. As shown in FIG. 21, information for the program highlighted in program list 432 is displayed in channel banner 344 and program summary 346. More particularly, channel banner 344 may indicate the channel number, call sign, and logo for the channel showing the highlighted program, and program summary 346 indicates the program title, running time, description, and characteristics for the highlighted program. As also shown, redundant information such as the date of the programs listed in program list 432 may be incorporated into theme and programs bar 422 when appropriate to save space in theme mode display 420. Stars 442 (or any other symbol) may be indicated for those programs in list 432 currently available for viewing. Likewise, other indicators can be displayed to indicate other program characteristics such as favorite channel, blocked channel, etc.

Once a subscriber has completed viewing the program list 432, the subscriber may select a program for viewing or

alternatively return to the theme list to select another theme. The subscriber may select a program for viewing by highlighting a program with cursor 440 and then pressing the select key (not shown). Set-top terminal 6 then switches to the corresponding channel when the program is a past or current program, or sets a reminder timer when the program is on at some future time. Alternatively, the subscriber may return to theme list 424 to select another theme by pressing the left arrow key (not shown) as indicated by left arrow indicator 438.

The title mode of the interactive program guide of the present invention is illustrated in FIG. 22. Like the theme mode, the title mode replaces date and time bar 348, channel list 350, and program grid 366 of the time mode display 15 (FIG. 16) with alphabet and program bar 446, alphabet list 448, and program list 450 as shown in title mode display 444. Alphabet list 448 displays the letters of the alphabet from A through Z and allows the subscriber to highlight a desired letter using cursor 452. Similarly to the theme mode 20 display, a default letter and program name are displayed upon entering the title mode display of the interactive program guide. The default letter and program name selected may be based upon the program currently displayed in program viewing window 340 or, alternatively, a program 25 highlighted in a previous mode of the interactive program guide. For example, if "CBS Sports Special" is being displayed in program viewing window 340, the default letter and program are accordingly "C" and "CBS Sports Special," respectively.

30 By using up and down arrow keys (not shown), as indicated by up and down arrow key indicators 454 and 456, a subscriber can highlight a desired letter with cursor 452 by scrolling alphabet list 448. As with other lists in the present invention, cursor 452 is preferably stationary within the IPG display and list 448 scrolls to make the cursor appear to move with respect to list 448. Once a desired letter has been highlighted, the subscriber may select that letter and enter program list 450 by pressing right arrow key (not shown) or select key (not shown), as indicated by the right arrow 40 indicator 458.

As shown in FIG. 23, once the subscriber has selected a letter from alphabet list 448 (FIG. 22), a selected letter indicator 460 replaces alphabet list 448 to indicate that a letter has been selected, and a cursor 462 appears in program list 450. This cursor is used to scroll through and highlight a program in program list 450. Up and down arrow indicators 464 and 466 are provided in display 444 to indicate to the subscriber that program list 450 is scrolled by pressing up and down arrow keys 128. As with other lists in the present invention, cursor 462 is preferably stationary within the IPG display and list 450 scrolls to make the cursor appear to move with respect to list 450.

55 In some embodiments of the present invention, a subscriber can see not only those programs beginning with the letter selected from alphabet list 448 by scrolling through program list 450, but also those programs beginning with other letters. This is facilitated by including in list 450 all programs for which data is available and sorting the list by program title. When displaying the list to a subscriber after the subscriber has selected a letter from list 448, set-top terminal 6 centers the displayed portion of list 450 on the portion of the list with program titles that begin with the selected letter.

60 65 Once a program has been highlighted using cursor 462, channel banner 344 and program summary 346 each display information for the highlighted program. More particularly,

channel banner 344 indicates the channel number, call sign, and logo for the channel showing the highlighted program, and program summary 346 indicates the program title, running time, description, and characteristics for the highlighted program. As with the theme mode display, stars 468 may be displayed adjacent to some programs to indicate that those programs are currently available for viewing. Similarly, other icons can be displayed to indicate other characteristics of the programs in program list 450 such as favorite channel, blocked channel, etc.

Once a subscriber has completed viewing program list 450, the subscriber may select another letter from alphabet list 448 by pressing the left arrow key (not shown) as indicated by left arrow indicator 468. Alternatively, by pressing the select key (not shown) when any program is highlighted by cursor 462, the program guide switches to the corresponding channel if the program is a past or current program, or sets a reminder timer if the program is on at some future time.

FIG. 24 illustrates the One-Touch Recording (OTR) feature of the present invention. From an interactive program guide display 470, pressing record key 472 with a program 474 highlighted causes a VCR timer to be set up for the highlighted program 474 and a to-be-recorded indicator 476 to appear in program summary 346, as illustrated in display 478. To fine-tune the settings of the VCR timer set up by the OTR feature, the subscriber may enter the general settings menu by pressing settings key 188. As shown in general settings menu 480, by highlighting and selecting VCR timers setting 482, the subscriber can modify the recording settings 484 for highlighted program 474.

As discussed in connection with the general settings menu (see FIG. 12), conflict detection and resolution is also incorporated into the OTR feature of the present invention. Conflict detection and resolution detects and alerts the set-top terminal subscriber of possible timer conflicts at the time the timers are set up to prevent timers from being erroneously set or over-written. For example, the OTR feature will alert the subscriber if an attempt is made to simultaneously record two or more programs as illustrated in FIG. 24. As shown, if after having set up a program to be recorded using One-Touch Recording (display 478), the subscriber attempts to record another program which is being shown at the same time by first highlighting (display 486) and then pressing record key 472, an attention banner 488 will be displayed (display 490) warning the subscriber of the conflict and enabling the conflict to be resolved.

The One-Touch Recording feature of the present invention also automatically warns the subscriber if an attempt is made to record an Impulse Pay-Per-View program without having previously made arrangements to purchase the program. As shown in FIG. 25, pressing record key 472 with an Impulse Pay-Per-View program 494 highlighted causes a buy option window 496 to be displayed. In addition to providing the subscriber with a summary of program information 498, "B" and "C" application definable keys 252 are monitored to determine if the subscriber would like to purchase the program or cancel the OTR event. If the subscriber presses "B" application definable key 252 with buy option window 496 displayed, a buy confirmation window 500 is provided to confirm the subscriber's purchase request. If in response to the buy confirmation window 500 the subscriber presses "C" application definable key 252, the display will revert to buy option window 496. If the subscriber presses "B" application definable key 252 in response to buy confirmation window 500, set-top terminal 6 will prompt the subscriber for a purchase pin through a

purchase PIN entry window 502. If the PIN entered by the subscriber matches the PIN's predefined value, the display will switch back to interactive program guide display 504 and note the future recording by providing a record icon 506 when the program to be recorded is a future event, or will immediately display the Impulse Pay-Per-View event, as illustrated by display 508, when the event is currently being shown.

FIG. 26 illustrates the reminder timer function of the present invention. With a program 510 highlighted within an interactive program guide display 512, pressing select key 136 causes one of three things to occur. First, if the time between the current time and the start time of the program selected exceeds a threshold amount and the program selected is not on an Impulse Pay-Per-View channel, a reminder timer icon 516 is displayed in program summary 346 to indicate that set-top terminal 6 has set a reminder timer to remind the subscriber to watch the selected program as illustrated by display 514. Second, set-top terminal 6 will display a buy option window 496 when the subscriber has selected a program on an Impulse Pay-Per-View channel. The interaction with this window matches that for the recording of Impulse Pay-Per-View programs as described in connection with FIG. 25. Third, if the current time is within a threshold amount of time before the starting time of the selected program, set-top terminal 6 will tune to the channel on which the selected program is to be aired as illustrated by display 518.

In addition to the information normally available in the program summary of the interactive program guide of the present invention, additional information may also be requested for a highlighted program by the subscriber pressing the information key on the set-top terminal or its remote control. FIG. 27 illustrates this process in a preferred embodiment of the present invention. After highlighting a program 523 within an interactive program guide display 522, the subscriber may request more information for the highlighted program by pressing information key 520 if the information provided in program summary 346 is inadequate. Set-top terminal 6 may then incorporate a loading data window 524 into display 522 while retrieving the requested information. Once the information has been retrieved, loading data window 524 is replaced by a full description display window 530. Full description display window 530 may include such information as a description of the program, the program's rating, the program's reviews, a list of the actors and actresses starring in the movie, etc. Once the subscriber has completed viewing full description display window 530, pressing "C" application definable key 252 will cause full description display 530 to be removed and a fresh interactive program guide display 522 to be displayed.

The information displayed in the interactive program guide of the present invention may be sent to set-top terminal 6 from headend 2 in at least three ways. First, the information may be periodically transmitted to set-top terminals 6, whereby the terminals store the information in their internal memory for use when necessary. Second, the information may be continuously transmitted to set-top terminals 6, whereby the terminals need not store the information in their internal memory, but rather accept the information required for display and discard all of the rest as the information is received. Third, the information may be requested when needed by a set-top terminal 6 over the return data channel of the present invention, after which headend 2 transmits the requested information back to the set-top terminal. Additionally, combinations of these

approaches can also be implemented. For example, a week's worth of data can be regularly transmitted by the headend and stored in the set-top terminal's internal memory for display on demand by the subscriber. Other data, however, can be specifically requested by the set-top terminal when the subscriber wishes to view program information not regularly stored in the set-top terminal. Alternatively, rather than requesting the not-regularly-stored information, the terminal can wait for the data to be transmitted in an approach similar to the second approach above. As another example, the program summary data can be received and stored in the terminal's internal memory on a regular basis, with any full description information being requested from the headend by the set-top terminal as required.

FIG. 28 illustrates a process for purchasing an Impulse Pay-Per-View (IPPV) event within the present invention. Selecting an IPPV channel from either an interactive program guide display 540 or a television display 542 causes an event barker 544 to be displayed. This barker informs the subscriber of a currently showing or upcoming IPPV event. Event barker 544 provides a summary indicator 546 and buy indicator 548 to instruct the subscriber to press "A" application definable key 252 to view a summary of purchased IPPV events 550 or press "B" application definable key 252 to purchase the IPPV event. Upon selecting to purchase the IPPV event, a buy confirmation window 552 is displayed instructing the subscriber to press "B" application definable key 252 again or press "C" application definable key 252 to go back to event barker 544. If the subscriber confirms the purchase of the IPPV event by pressing "B" application definable key 252 at buy confirmation window 552, a PIN entry screen 554 will prompt the subscriber to enter a predefined purchase PIN. If the subscriber correctly enters the predefined purchase PIN and the IPPV event has already started, the set-top terminal will immediately tune to and display the IPPV event as is illustrated in display 560. As is also shown, a program information banner 562 may be displayed momentarily to indicate to the subscriber that the program has been tuned and inform the subscriber of the program's elapsed time. If the subscriber has correctly entered the predefined purchase PIN and the event has not yet started or is a Near-Video-On-Demand (NVID) or Pay-Per-Day (PPD) event, a countdown barker 556 will be displayed informing the subscriber of the time remaining until the beginning of the next showing of the program. At the time the program begins, the set-top terminal will automatically tune to and display the IPPV event. As illustrated by barker 558, the set-top terminal may give the subscriber the option of entering an IPPV event during the current showing by pressing "A" application definable key 252 when the IPPV event is a NVID or PPD event.

FIG. 29 illustrates an alternative means through which a subscriber may select an IPPV event for purchase rather than selecting individual channels for each IPPV event. As shown an interactive barker 564 allows the subscriber to select an IPPV program title from a list of titles 566 and a time from a list of times 568. The subscriber may scroll through the lists of titles 566 by pressing up and down arrow keys (not shown) as indicated by up and down arrow indicators 572 and 574. After selecting a program, an IPPV program information banner 570 then indicates to the subscriber the program price, channel, rating, etc. To scroll the list of times 568, the subscriber presses left and right arrow keys (not shown) as indicated by left and right arrow indicators 576 and 578. Much like event barker 544 (FIG. 28), from barker 564 the subscriber may display a summary of IPPV purchases by pressing "A" application definable key 252 or

purchase the selected program by pressing "B" application definable key 252.

Referring to FIG. 30, the operation of the countdown mechanism for IPPV purchases is now described. After a countdown barker 556 is displayed confirming the purchase of a future IPPV event, the subscriber is free to change channels to watch another program 580 while awaiting the IPPV event. If a problem occurs in purchasing the desired IPPV event, a message banner 582 will be displayed to indicate to the subscriber the presence of a problem. If the subscriber presses select key 136 in response to banner 582, a more detailed window 584 will be displayed to indicate to the subscriber how to proceed. Upon exiting window 584 by pressing "C" application definable key 252, the subscriber will return to event barker 544 if the purchase problem has not been resolved. If the purchase problem has been resolved, an updated countdown barker 586 will be displayed. If no purchase problems are encountered while viewing program 580, a notification banner 588 will be displayed at least one time period before the beginning of the IPPV event. By pressing select key 136 in response to barker 588, the subscriber will cause the set-top terminal to display an updated countdown barker 586. At the time the IPPV event begins, the IPPV event will be selected and displayed as illustrated by display 590. Along with display 590, a program information banner 592 may be displayed to indicate to the subscriber that the IPPV event has begun.

Preferred embodiments of the present invention incorporate a method for canceling pending IPPV purchases as illustrated in FIG. 31. By entering an IPPV summary display 594 from a countdown barker 556 (or any other display) by pressing "A" application definable key 252, a list 596 of pending and past IPPV purchases is displayed. After using up and down arrow keys 128 to highlight a pending purchase 598, the subscriber may cancel purchase 598 by pressing "C" application definable key 252. Once purchase 598 has been canceled, an updated summary display 600 is presented. After a brief period (e.g., 30 seconds) of inactivity, the display will revert to countdown barker 556 (if the IPPV event of barker 556 is still pending) or an event barker 544 for that IPPV channel.

The free preview feature of the present invention is illustrated in FIG. 32. After selecting an IPPV channel from an interactive program guide display 540 or a normal television display 542, set-top terminal 6 may display a preview barker 602 showing a free preview of an IPPV event in a preview window 604. In response to barker 602, the subscriber may elect to buy the IPPV event by pressing "B" application definable key 252 as indicated by a buy option indicator 606. Set-top terminal 6 will then display a confirmation barker 552 to confirm the purchase request. In response, the subscriber may confirm the purchase request by pressing "B" key 252 again after which set-top terminal 6 will continue the IPPV purchase in accord with FIG. 28, or cancel the request by pressing "C" application definable key 252 after which the display will revert to preview barker 602. If the subscriber does not press "B" key 252 in response to preview barker 602 and the time period for the preview expires, a preview expiration barker 608 will be displayed. Expiration barker 608 allows the subscriber to return to event barker 556 by pressing "C" application definable key 252 or to purchase the IPPV event, and therefore continue to the confirmation barker 552, by pressing "B" application definable key 252.

Preferred embodiments of the present invention also provide for the operation of Near-Video-On-Demand (NVID) programs. NVID allows a program to be viewed

more frequently than traditional IPPV events. This is accomplished in the present invention by transmitting the same program using two or more sources, each beginning a fixed period of time after the others. For example, transmitting an hour long program on four channels, each fifteen minutes apart, allows the program to be viewed beginning every fifteen minutes. In this way, the video is near on demand—the prospective subscriber only has to wait at most fifteen minutes to view the program.

A pause feature is incorporated into the NVOD feature of the preferred embodiments of the present invention as illustrated in FIG. 33. The pause feature operates by presenting a pause barker 616 when the subscriber presses pause key 612 while viewing a NVOD event 614. Pause barker 616 notifies the subscriber that the program is "paused" and provides a countdown timer 618 informing the subscriber when the program will resume. This countdown timer begins with a time equivalent to the delay between consecutive transmissions of the same program. Upon expiration of countdown timer 618, the pause feature automatically switches to subsequent transmission 622 of the program. In this way, the program appears to have been paused for the fixed period of time. Alternatively, the subscriber can elect to continue viewing current transmission 614 of the program by pressing play key 610 as indicated by play indicator 620. By pressing play key 610, pause barker 616 is removed from display, transmission 614 is displayed, and any part of transmission 614 during which pause barker 616 was displayed is lost.

Similarly, NVOD provides skip forward and skip backward capabilities as well. As illustrated in FIG. 34, pressing fast-forward (FF) key 634 while viewing an nth transmission 614 of an NVOD program causes set-top terminal 6 to tune to (n-1)th transmission 624 of the same NVOD program—that is the transmission which began immediately prior to the nth transmission. Pressing FF key 634 again causes the set-top terminal to select (n-2)th transmission 626 of the NVOD program. Likewise, pressing rewind (REW) key 636 while viewing nth transmission 614 of an NVOD program causes the set-top terminal to tune to (n+1)th transmission 628 of the NVOD program. In instances where the subscriber presses REW key 636 and an (n+2)th transmission has not yet begun, a delay barker 630 is displayed indicating that the NVOD program cannot be skipped backward any further. Delay barker 630 displays a countdown timer 638 indicating to the subscriber the amount of time remaining before the (n+2)th transmission of the NVOD program begins. Pressing REW key 636 again with the delay barker 630 displayed causes the barker to indicate to the subscriber that the program cannot be further skipped backward by 50 blinking the "elapsed time" text 640.

The present invention also incorporates a message transmission system. Messages may be sent from headend 2 to one or more subscribers at one or more set-top terminals 6, or may be sent from one subscriber within a household to another (e.g., automatic message from mother to son sent every Monday night at 8:15 p.m.: "take out trash"). The messages may be displayed upon the occurrence of a pre-determined action by the subscriber or immediately by overriding whatever channel was previously being viewed by the subscriber. For example, FIG. 35 illustrates the display of an emergency broadcast message 642. As indicated by select key indicator 644, the subscriber can press the select key (not shown), or any other key, to get more information regarding the message being displayed. In response to the subscriber pressing select key 136, set-top terminal 6 may switch to another channel to display more

information or display another message. Additionally, messages may be configured to turn on set-top terminal 6 and an attached television or other appliance to automatically display an important message. In this way, a subscriber can be effectively alerted to a crisis situation without the subscriber watching television at the time of the transmission. Messages can also activate a particular service within the set-top terminal. For example, a message can cause the set-top terminal to switch to and display a particular service on the subscriber's television. To indicate the presence of a message in set-top terminal 6, an LED on the terminal's face may illuminate or an icon may be incorporated into the display screen until a subscriber presses a key or a fixed amount of time has passed.

One skilled in the art will appreciate that the present invention can be practiced by other than the described embodiments, which are presented for purposes of illustration and not of limitation, and the present invention is limited only by the claims which follow.

20 What is claimed is:

1. An interactive program guide for displaying information regarding a plurality of television programs on an interactive program guide display, said interactive program guide comprising:

25 a grid having a plurality of cells, each cell corresponding to a television program; and an indicator for designating a cell, said indicator anchored at a fixed position with respect to said display; wherein: said grid is moveable with respect to said indicator in two directions in each of two dimensions such that different cells can be designated by said indicator at said fixed position by movement of said grid.

30 2. The interactive program guide of claim 1 wherein said cells move horizontally and vertically with respect to said indicator.

35 3. The interactive program guide of claim 1 wherein said cells have a plurality of sizes and said indicator changes size to highlight a cell after said grid is moved.

40 4. The interactive program guide of claim 1 wherein said cells scroll in at least one of said two dimensions with respect to said indicator.

45 5. The interactive program guide of claim 1 wherein said indicator comprises a cursor.

60 6. A system for providing an interactive program guide that displays information regarding a plurality of television programs on an interactive program guide display, said system comprising:

a receiver for receiving said information;

a display driver for generating displayable video output for said display;

a grid control for receiving user inputs; and

a processor for causing said display driver to: display on said display a grid having a plurality of cells, each cell including at least a portion of said information received by said receiver;

display on said display an indicator for designating a cell, said indicator anchored at a fixed position with respect to said display; and

move said grid on said display in two directions in each of two dimensions with respect to said indicator at said fixed position in accordance with said user inputs received by said grid control.

65 7. The system of claim 6 wherein said grid can be moved horizontally and vertically with respect to said indicator.

8. The system of claim 6 wherein said cells have a plurality of cell sizes and said indicator can change size to

highlight a cell after said processor causes said display driver to move said grid.

9. The system of claim 6 wherein said indicator comprises a cursor.

10. A system for providing an interactive program guide that displays information regarding a plurality of television programs on an interactive program guide display, said display including a grid of cells, each cell corresponding to a television program, said system comprising:

means for designating a cell on said display at a fixed position with respect to said display; and

means for moving said grid in each of two dimensions with respect to said fixed position such that different cells can be designated by said means for designating by movement of said grid, said movement independent of said means for designating.

11. The interactive program guide of claim 10 wherein said means for moving moves said grid horizontally and vertically with respect to said fixed position.

12. The interactive program guide of claim 10 wherein said means for moving scrolls said cells in at least one of said two dimensions with respect to said fixed position.

13. The interactive program guide of claim 12 wherein said means for moving scrolls said cells horizontally and vertically with respect to said fixed position.

14. A method of designating a cell in a grid of cells, said cells displaying information regarding a plurality of television programs on an interactive program guide display, said method comprising:

designating any cell at only one fixed position on said display;

moving said grid in a first direction in a first dimension to designate a first cell upon said first cell moving into said fixed position;

moving said grid in a second direction in said first dimension to designate a second cell upon said second cell moving into said fixed position;

moving said grid in both said first direction in said first dimension and said first direction in said second dimension to designate a third cell upon said third cell moving into said fixed position; and

moving said grid in both said second direction in said first dimension and said second direction in said second dimension to designate a fourth cell upon said fourth cell moving into said fixed position, wherein said first and second directions of said first dimension are opposite each other.

15. The method of claim 14 wherein said moving said grid in both said first direction in said first dimension and said first direction in said second dimension comprises moving said grid horizontally rightward and vertically downward with respect to said fixed position.

16. The method of claim 14 wherein said moving said grid in both said second direction in said first dimension and said second direction in said second dimension comprises scrolling said cells horizontally leftward and vertically upward with respect to said fixed position.

17. An interactive program guide for displaying information regarding a plurality of television programs on an interactive program guide display, said interactive program guide comprising:

a grid having a plurality of cells, each cell corresponding to a television program; and

an indicator having a fixed position on said display; wherein:

said grid is moveable in each of two dimensions with respect to said indicator, said indicator highlighting a cell when said cell is positioned at said fixed position, said grid movement independent of said indicator fixed position.

18. The interactive program guide of claim 17 wherein said indicator comprises a cursor.

19. Software on a computer readable medium for designating a cell in a grid of cells, said cells displaying information regarding a plurality of television programs on an interactive program guide display, said software comprising; establishing only one fixed position on said display at which cells are designated;

allowing said grid to move with respect to said fixed position in each of two directions in each of two dimensions; and

designating a cell when said cell is positioned at said established position.

20. A method of designating a cell in a grid of cells, said cells displaying information regarding a plurality of television programs on an interactive program guide display, said method comprising;

designating a cell on said display at a fixed position with respect to said display; and

moving said grid in each of two dimensions with respect to said fixed position such that different cells can be designated at said fixed position by said moving of said grid, said moving independent of said designating.

* * * * *



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(12) **United States Patent**
Voit et al.

(10) **Patent No.: US 6,798,751 B1**
(45) **Date of Patent: Sep. 28, 2004**

(54) **CUSTOMER PREMISES EQUIPMENT FOR VERTICAL SERVICES INTEGRATION**

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(73) Assignee: Verizon Communications Inc., New York, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 111 days.

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(22) Filed: Dec. 7, 2000

Related U.S. Application Data

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(51) Int. Cl.⁷ H04J 3/16

(52) U.S. Cl. 370/252; 370/469; 709/230

(58) Field of Search 370/252, 231, 370/352, 389, 395, 401, 402, 412, 413, 428, 465, 466, 467, 469; 709/225, 227, 230, 236, 223; 376/351, 392, 395.32, 395.5

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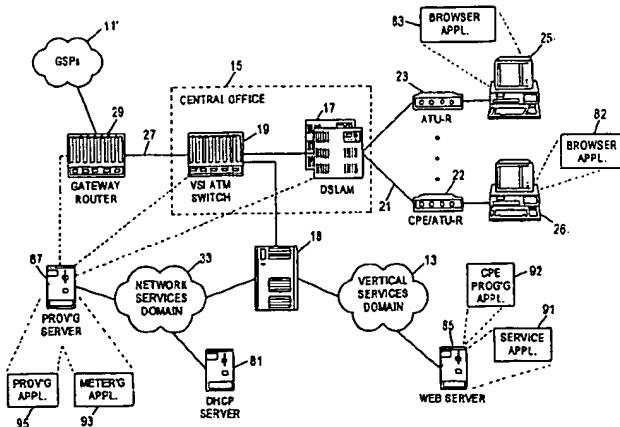
Primary Examiner—Brian Nguyen

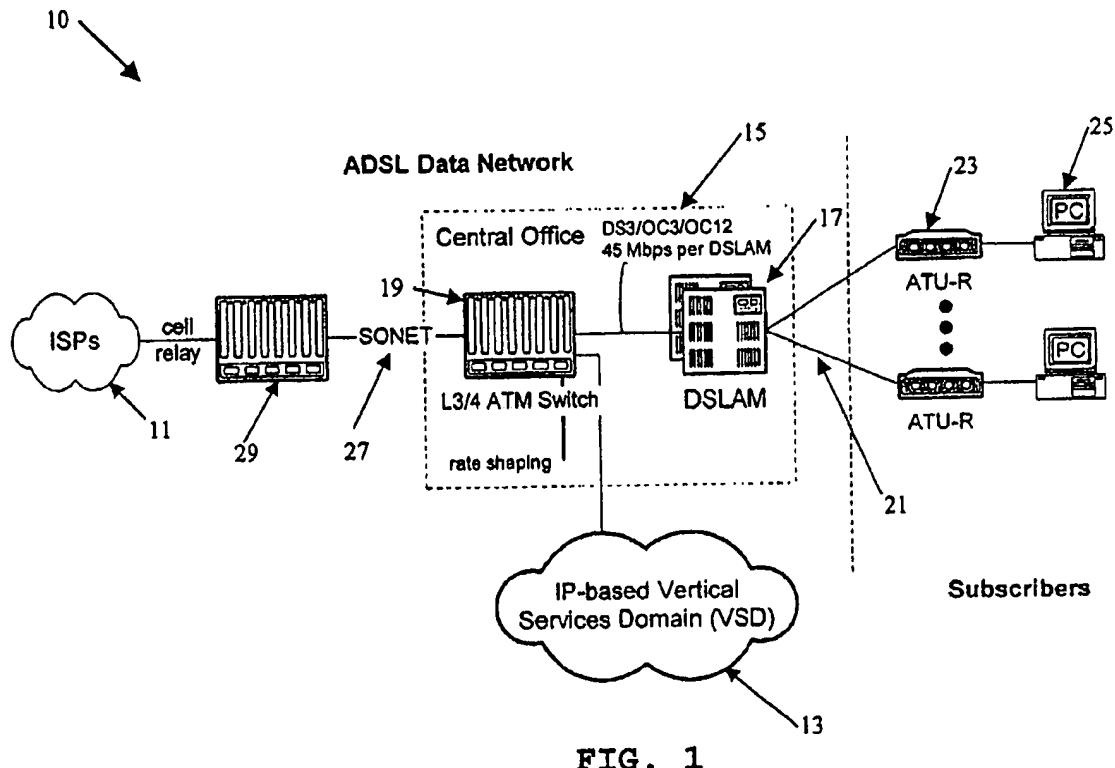
(74) *Attorney, Agent, or Firm*—Leonard C. Suchyta, Esq.; Michael Stewart, Esq.

ABSTRACT

Offering vertical services to subscribers and service providers is an avenue to immediately improve the competitiveness of digital subscriber line access service, for example of the type offered by a local exchange carrier. To deliver high-quality vertical services, however, the underlying ADSL Data Network (ADN) or the like needs to establish Quality of Service (QoS) as a core characteristic and offer an efficient mechanism for insertion of the vertical services. The inventive network architecture introduces QoS into the ADN, in a manner that enables the delivery of sophisticated and demanding IP-based services to subscribers, does not affect existing Internet tiers of service, and is cost-effective in terms of initial costs, build-out, and ongoing operations. The architecture utilizes a switch capable of examining and selectively forwarding packets or frames based on higher layer information in the protocol stack, that is to say on information that is encapsulated in the layer-2 information utilized to define normal connectivity through the network. The switch enables segregation of upstream traffic by type and downstream aggregation of Internet traffic together with traffic from a local vertical services domain. Customer Premises Equipment (CPE) located between the ADN and customer premises data equipment examines frames received from the data equipment and modifies the frames according to the destination of the frames' payloads. This CPE also enforces QoS guarantees in the upstream direction and security-related access control lists.

27 Claims, 15 Drawing Sheets





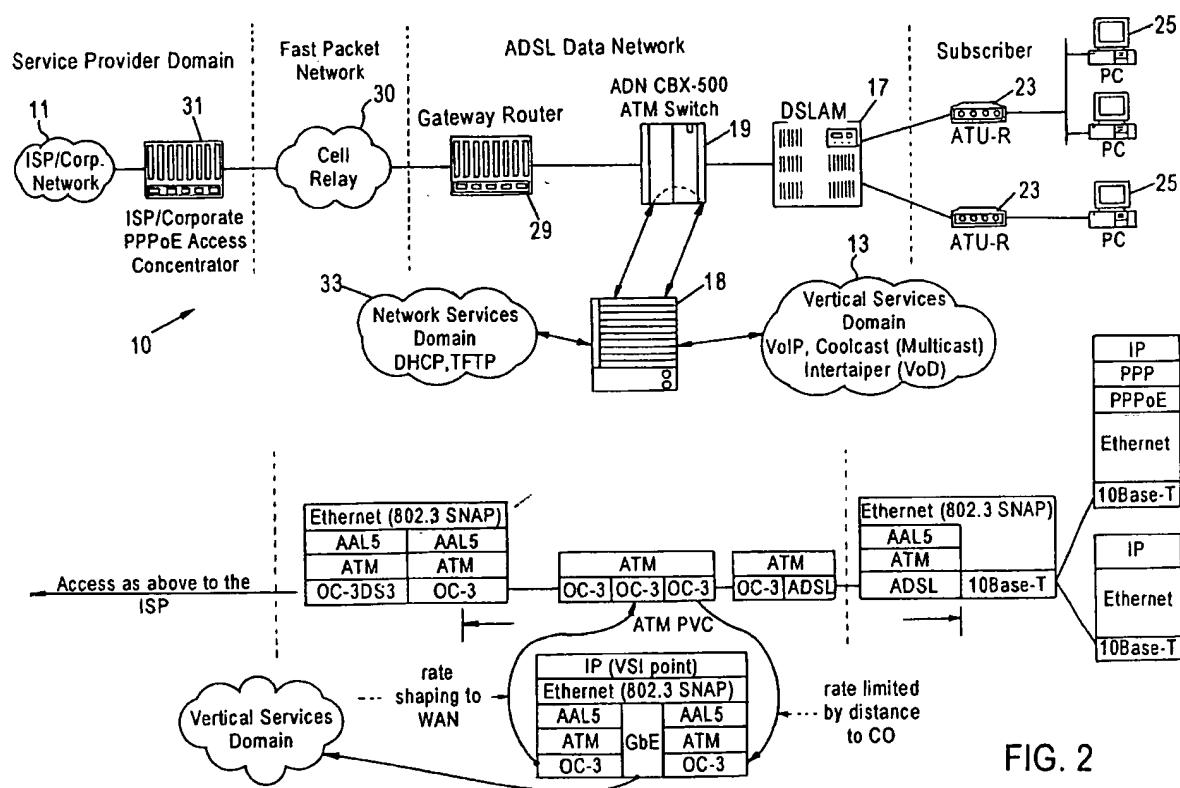


FIG. 2

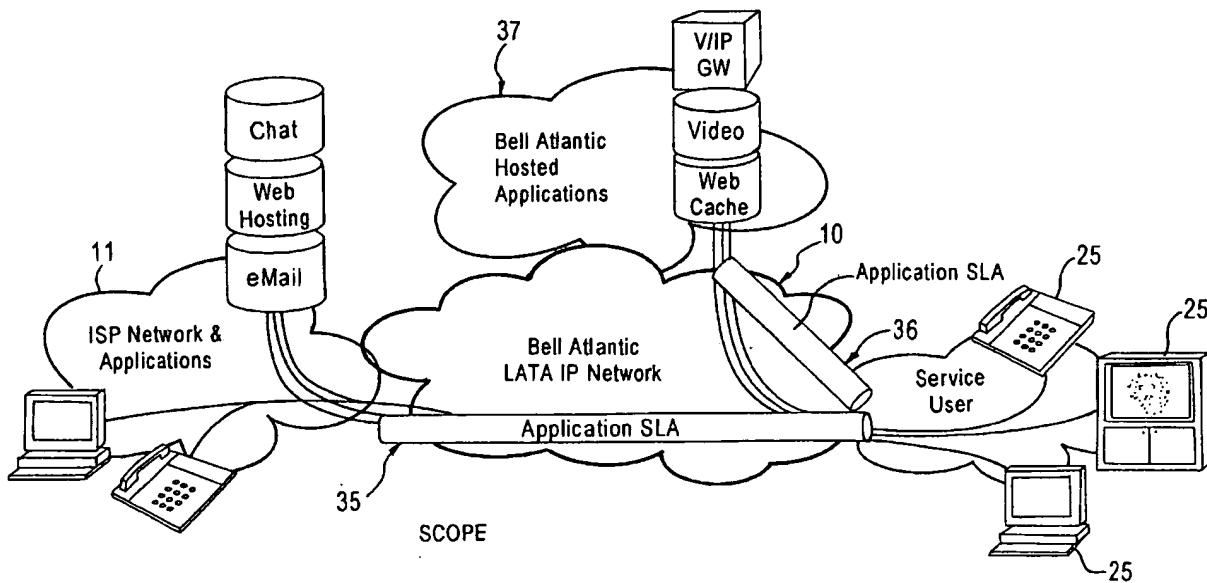


FIG. 3

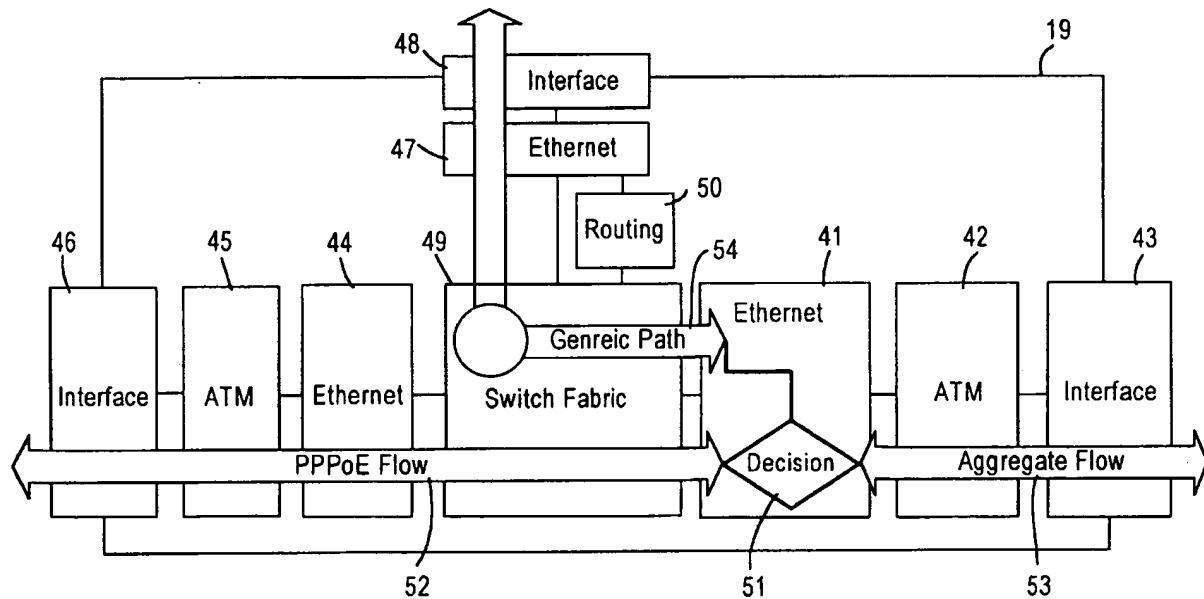


FIG. 4

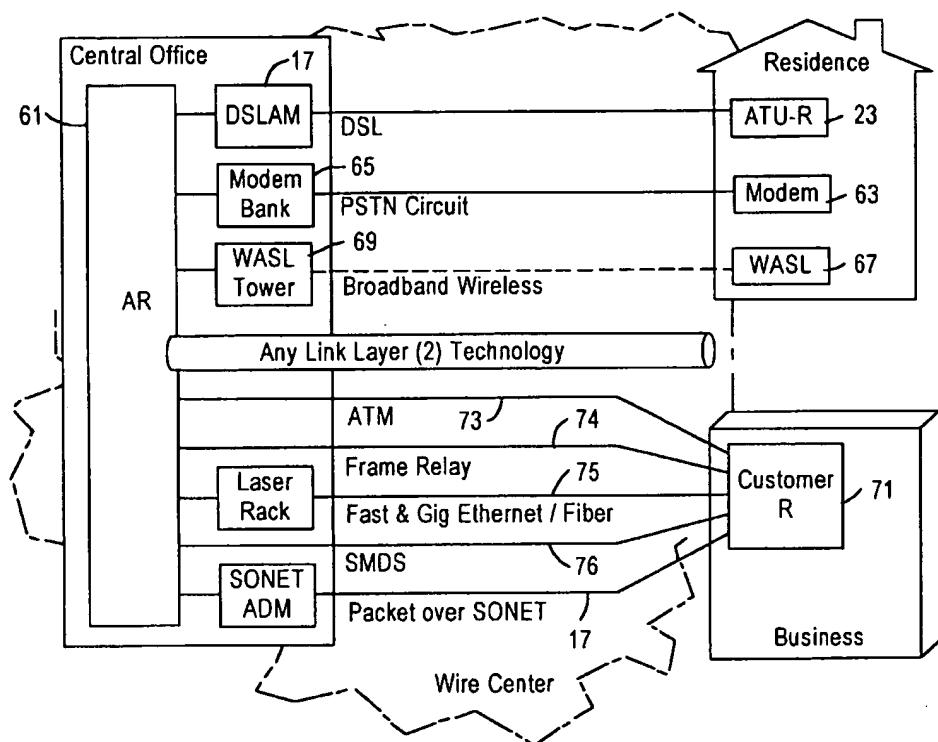


FIG. 5

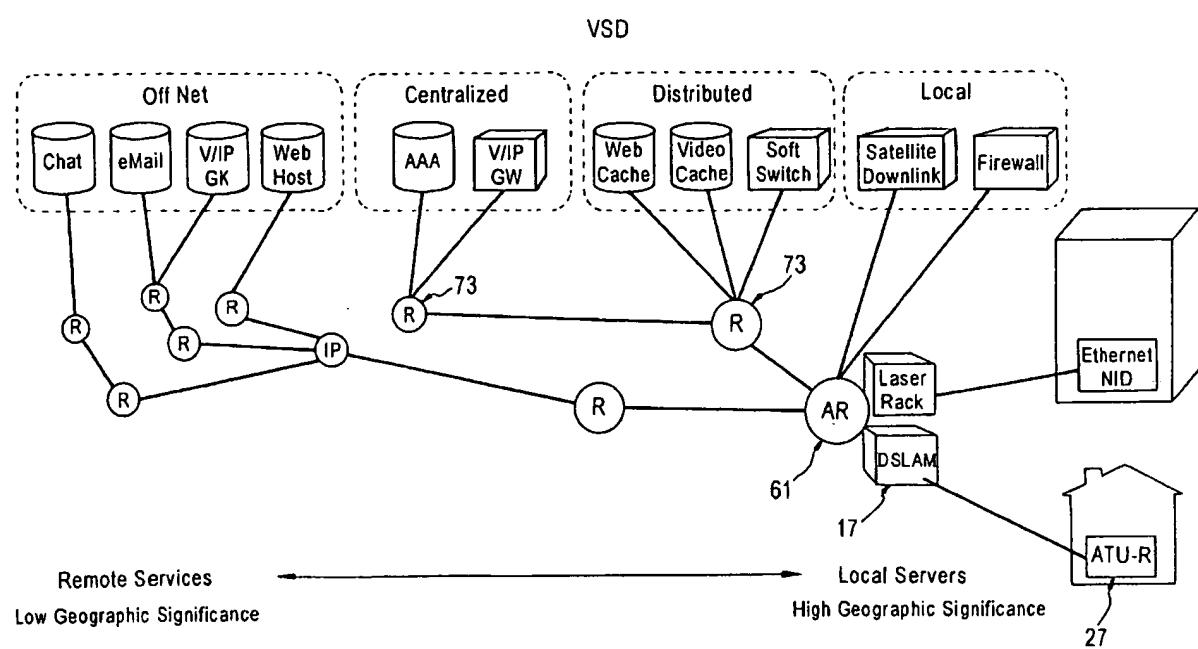


FIG. 6

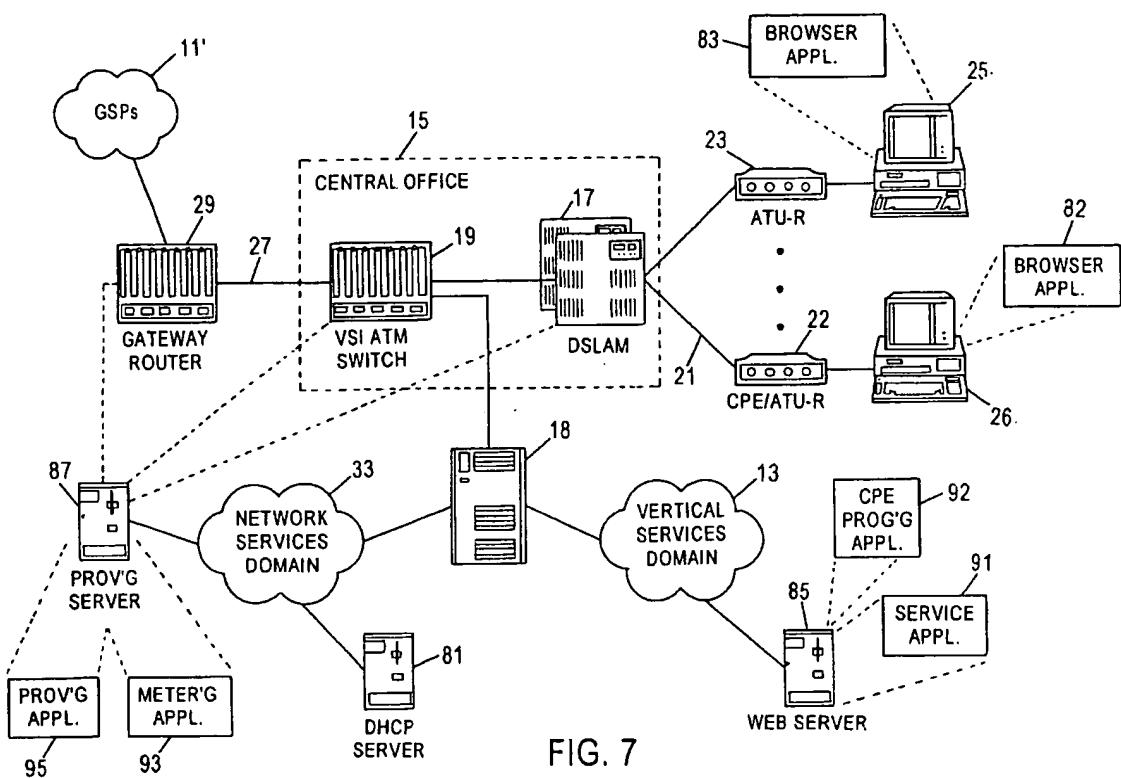


FIG. 7

FIG. 8

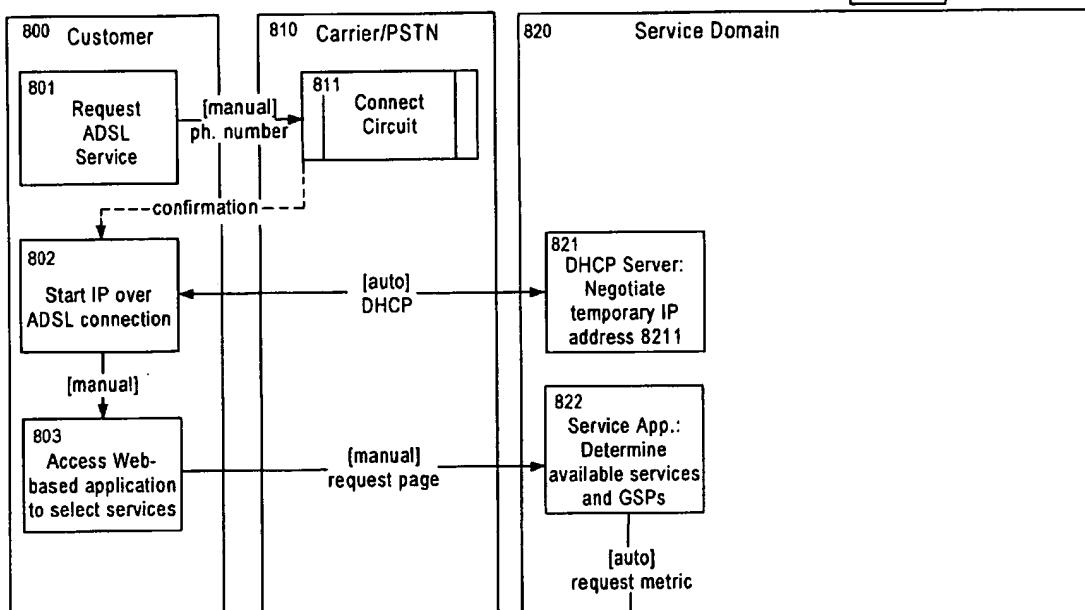
FIG. 8A
FIG. 8B

FIG. 8A

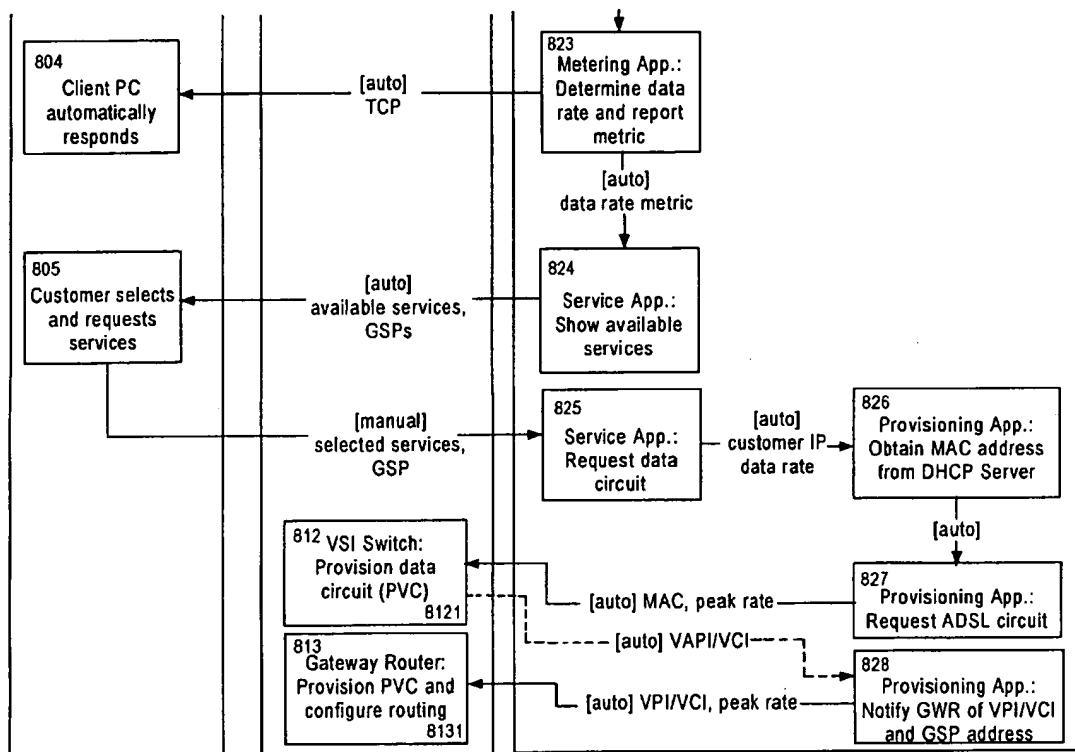


FIG. 8B

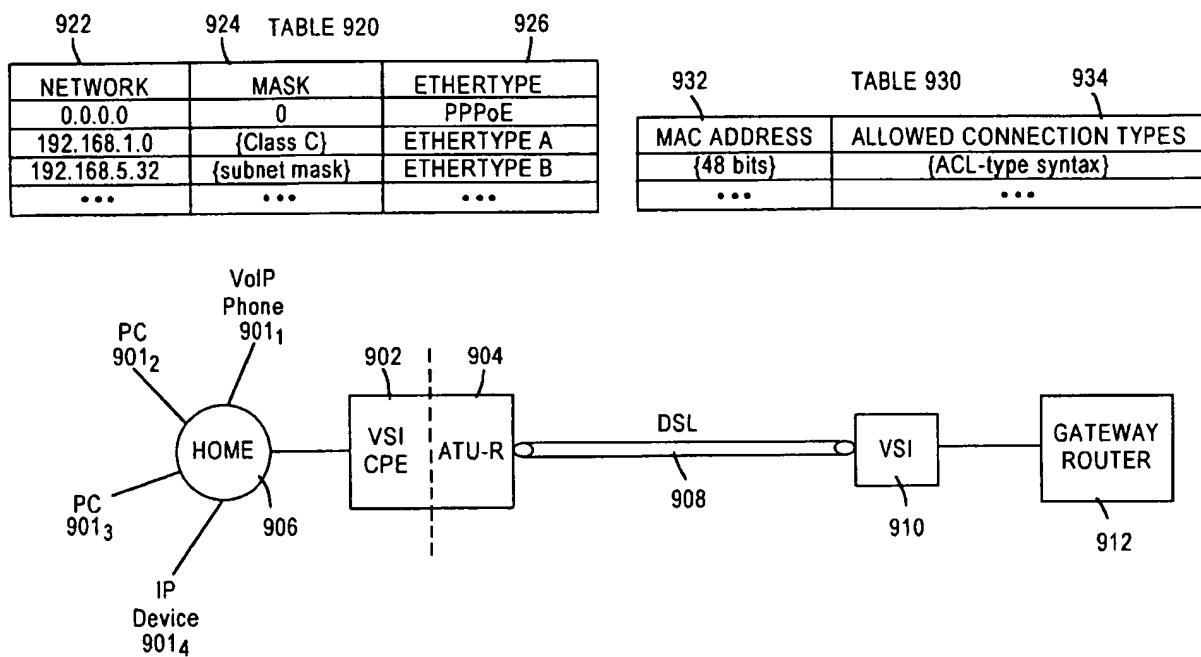


FIG. 9

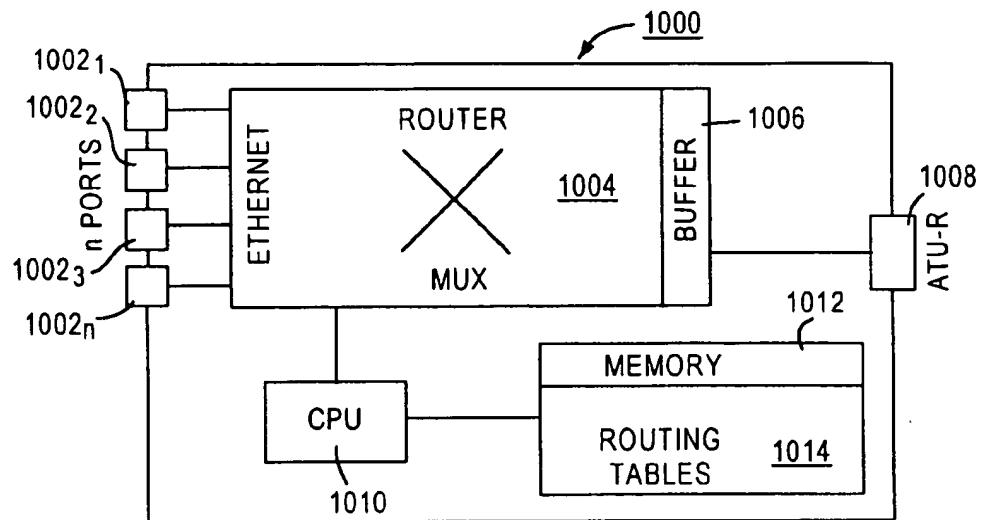


FIG. 10

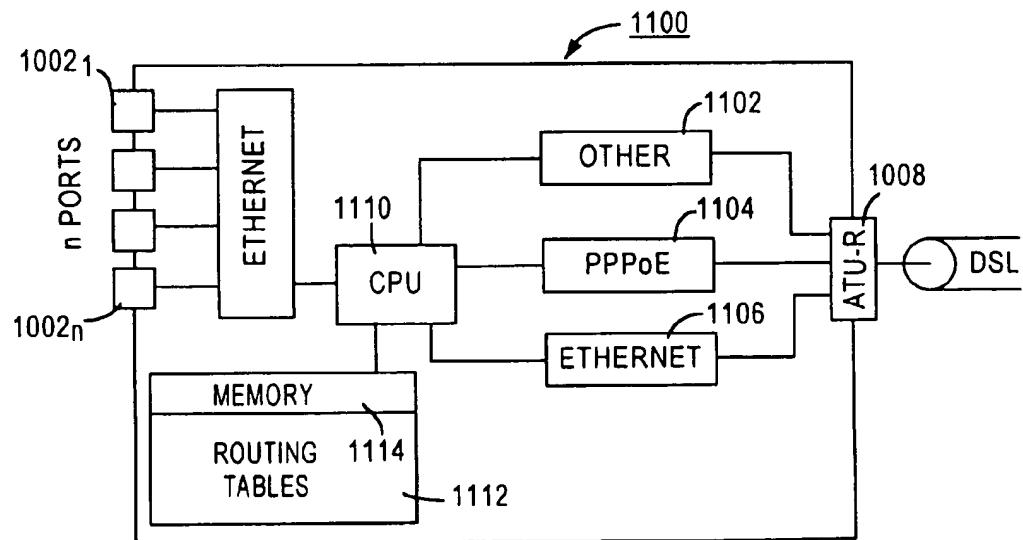


FIG. 11

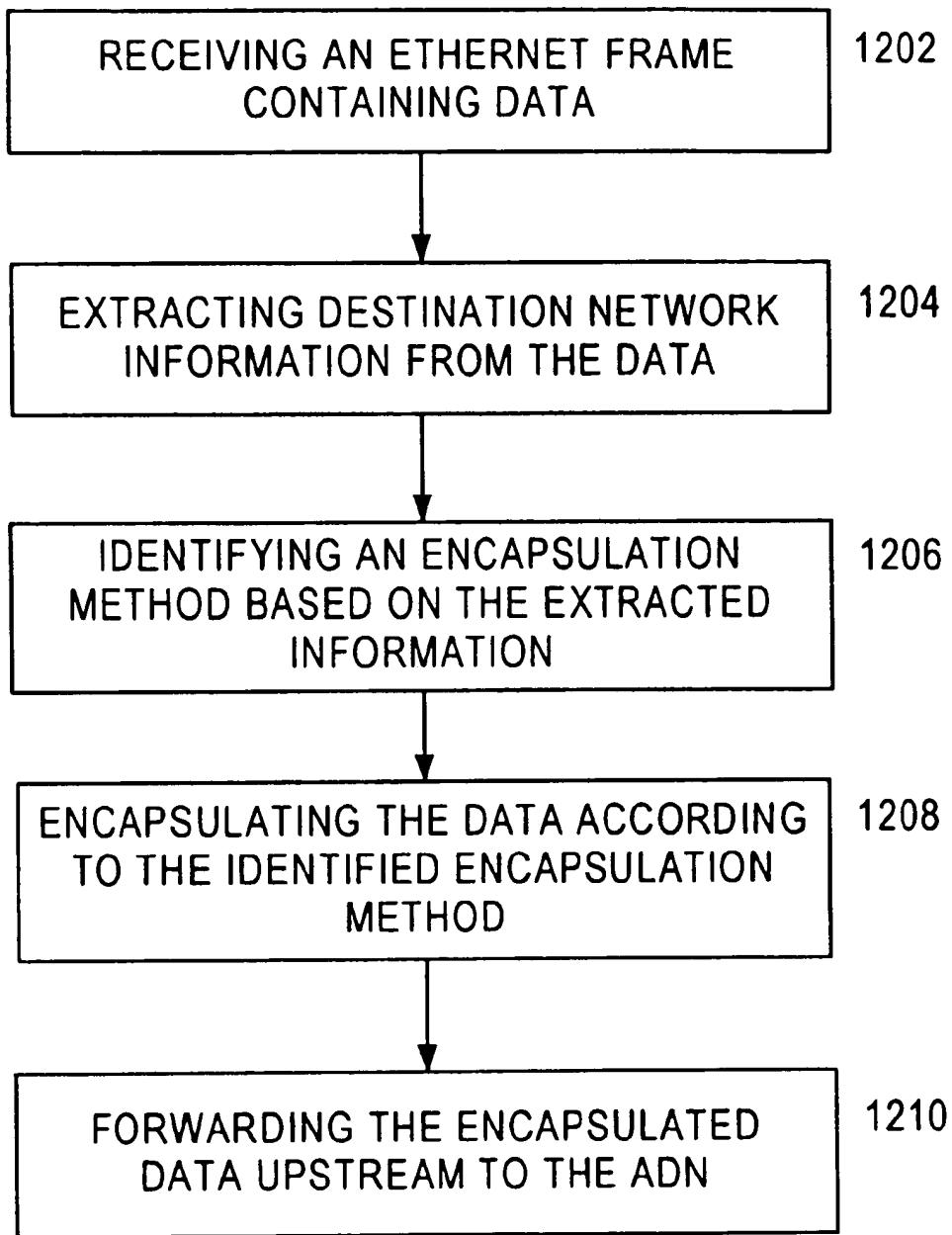


FIG. 12

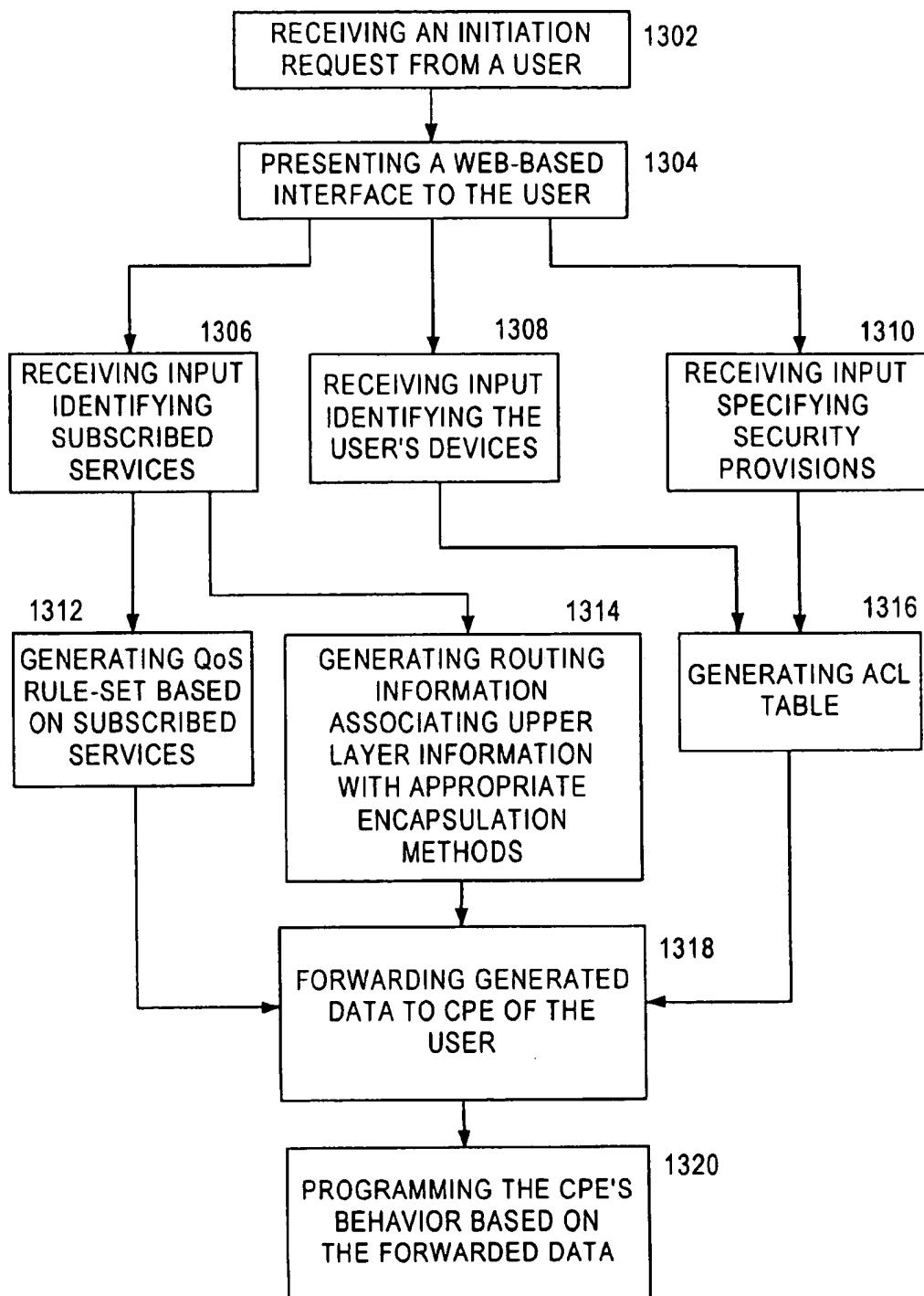
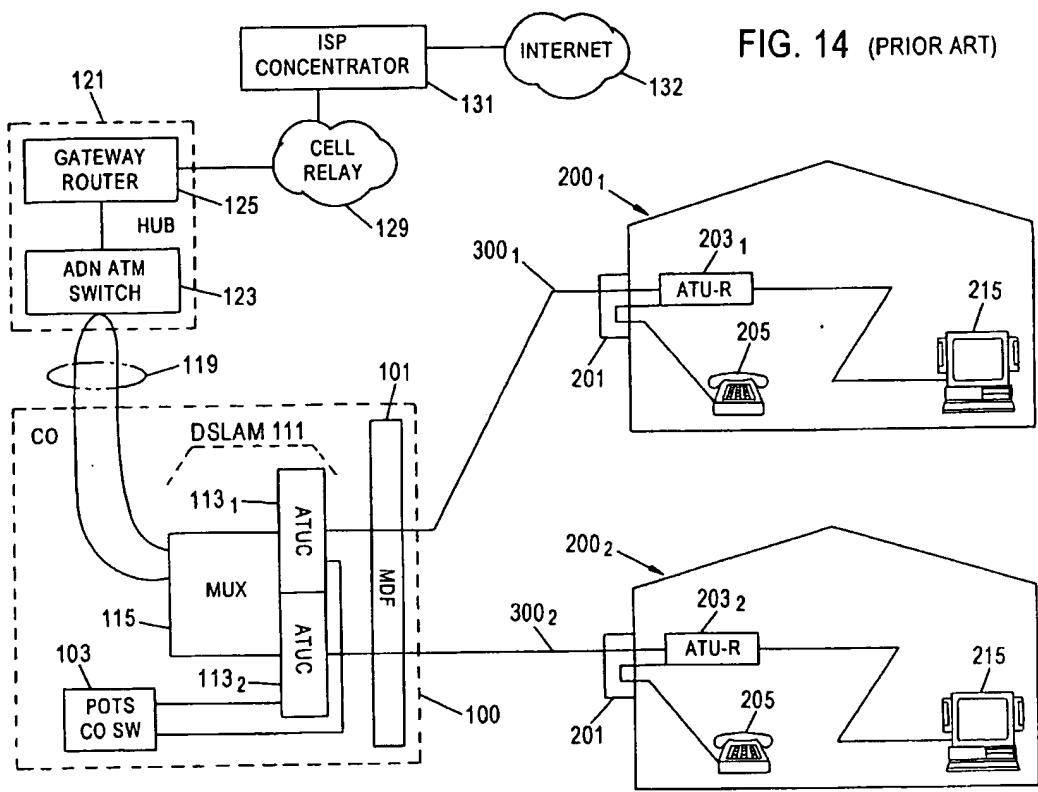


FIG. 13

FIG. 14 (PRIOR ART)



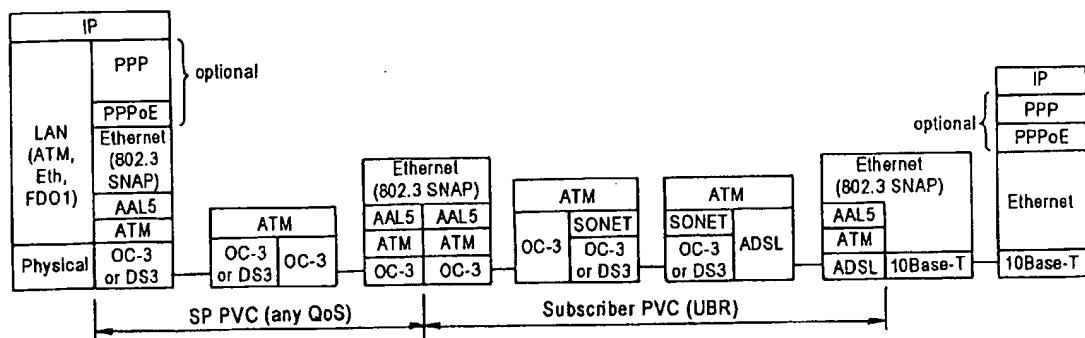
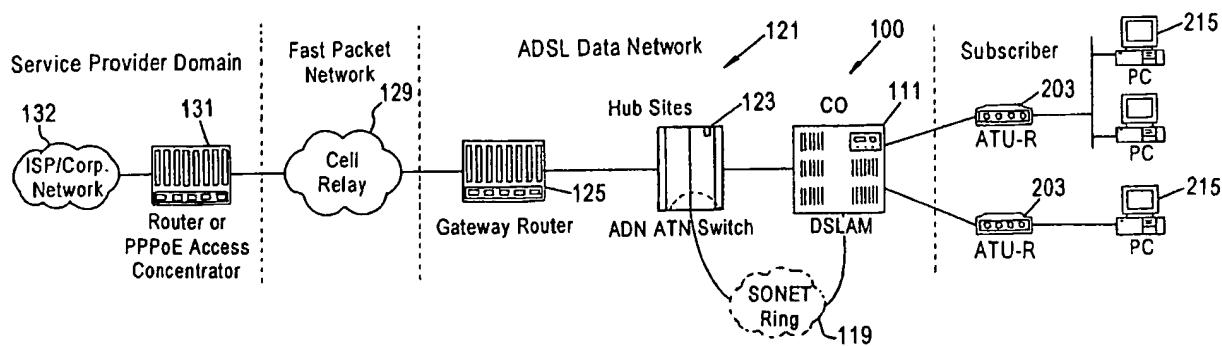


FIG. 15 (PRIOR ART)

CUSTOMER PREMISES EQUIPMENT FOR VERTICAL SERVICES INTEGRATION

RELATED APPLICATIONS

This application is a continuation in part of U.S. patent application Ser. No. 09/635,695, filed Aug. 10, 2000 entitled "SUPPORT FOR QUALITY OF SERVICE AND VERTICAL SERVICES IN DIGITAL SUBSCRIBER LINE DOMAIN" and U.S. patent application Ser. No. 09/652,140, filed Aug. 31, 2000 entitled, "AUTOMATED SERVICE PROVISIONING IN COMBINATION OF VERTICAL SERVICES AND DIGITAL SUBSCRIBER LINE DOMAINS", the disclosures of which are incorporated herein entirely by reference.

FIELD OF THE INVENTION

Certain concepts involved in the present invention relate to techniques for implementing data communication services, for example in a local access network utilizing digital subscriber line technology, to support quality of service (QoS) and local introduction of vertical services. Other concepts involved in the present invention relate to techniques for automatically provisioning services through such a network. Other concepts involved in the present invention relate to placement of protocol stack shims on equipment that is separate from the devices used by a customer.

BACKGROUND

Modern society continues to create exponentially increasing demands for digital information and the communication of such information between data devices. Local area networks use a network, cable or other media to link stations on the network for exchange of information in the form of packets of digital data. These networks have proven quite successful in providing data communications in commercial applications. However, the common local area network architectures require installation of specialized wiring and use of specific wiring topologies. For example, the most popular network protocols, such as Ethernet, require special rules for the wiring, for example with regard to quality of wire, range of transmission and termination. Furthermore, to extend communications to a wider domain still requires connection of at least one node of the local area network out to a wider area network, such as the network of an Internet Service Provider (ISP). High speed links enabling such wide area access from a LAN domain, for example using T1 lines, are quite expensive and justified only for hi-end commercial users.

The most common form of computer-to-computer communication in use today, particularly for wide area communications, still relies on modems and analog telephone network connections. The telephone-based operation provides the voice grade analog modem a unique power, the necessary connections are virtually ubiquitous. Such modems can communicate via almost any telephone line or wireless telephone (e.g. cellular) to any other such telephone connection, virtually anywhere in the world. The telephone network, however, was designed to provide approximately 3.3 kHz of analog voice bandwidth. Consequently, the data rates that are possible through the telephone network are quite low. Even with a variety of recent enhancements, the data speeds remain at or below 56 kbps.

Integrated Services Digital Network (ISDN) offers somewhat faster data communications and the capacity for con-

current data and voice telephone services. The 160 kb/s capacity carries two bearer (B) channels, each at 64 kb/s, one data (D) channel at 16 kb/s and overhead information in a 16 kb/s embedded operations channel (EOC). The two B-channels may be used separately, for example, for one voice telephone call and one data communication session. The D-channel typically is used for signaling, for call set-up and the like. Some applications allow aggregation of the channels, to combine the B-channels and possibly the D-channel to provide data communications up to the combined rate of 144 kb/s. However, these data rates offered by ISDN already are too slow for many multimedia applications. The high-speed and wide availability of modern personal computers (PCs) continually gives rise to ever more sophisticated multimedia applications. Communications for such applications, typically between the PC and the Internet, already are driving the need for speed to rates far above those available on normal ISDN lines.

A number of technologies are being developed and are in early stages of deployment, for providing substantially higher rates of data communication, for example ranging from 640 kb/s to 7.1 Mb/s. For example, cable television companies are now beginning to offer 'cable modem' services, which allow customers to communicate data over available bandwidth on the coaxial cable of a cable television network. After considering several other options, a number of the local telephone carriers are working on enhancements to their existing copper-wire loop networks, based on various xDSL technologies.

The term xDSL here is used as a generic term for a group of higher-rate digital subscriber line communication schemes capable of utilizing twisted pair wiring from an office or other terminal node of a telephone network to the subscriber premises. Examples under various stages of development include ADSL (Asymmetrical Digital Subscriber Line), HDSL (High data rate Digital Subscriber Line) and VDSL (Very high data rate Digital Subscriber Line).

The telephone carriers originally proposed use of ADSL and similar high-speed technologies to implement digital video services, for example in networks sometimes referred to as video 'dialtone' networks. The ADSL line technology provided a mechanism for high-speed transport of MPEG encoded video information to video terminal devices in the customers' homes. Examples of such ADSL-based video dialtone networks are disclosed in U.S. Pat. Nos. 5,247,347, 5,410,343 and 5,621,728. The carriers are now deploying a range of xDSL data services targeted at high-speed Internet access and high-speed access to private data networks. U.S. Pat. No. 5,790,548 to Sistanizadeh et al. discloses an example of an ADSL based data network, e.g. for high-speed access to the Internet and to corporate LANs.

The current design goals of DSL data networks for Internet access do not support high-end vertical services, that is to say services demanding IP-based applications that require assurance of some level of quality of service (QoS). For example, packet-switched Voice over IP (VoIP) requires low latency, low jitter (i.e., a relatively constant bit rate), and non-correlated packet loss. Streaming video has similar requirements, and in addition, requires high bandwidth. DSL data networks designed to support high speed Internet and Intranet access have been optimized to support traffic that is bursty and is not sensitive to latency or jitter. For example, current implementations supporting ATM cell traffic employ the Unspecified Bit Rate (UBR) class of service, which does not provide any bandwidth or delay guarantees. Consequently, transport of video materials through such

DSL data networks inflicts video delays, loss of audio/video synchronization, and image fragmentation.

Furthermore, lengthy bandwidth intensive sessions for video or other broadband applications may degrade the throughput to all other subscribers served through a shared node, such as a gateway router or a concentrated link. For two-way video, upstream will have even worse quality and throughput problems, due to the best effort nature of the DSL data network implemented for Internet access and because the upstream bandwidth is significantly less than that of the downstream channel.

To appreciate the situation and problems, it may be helpful here to consider an ADSL data implementation of a local access network, as a representative example, in somewhat more detail. FIG. 14 is a block diagram of a typical ADSL data network of the type currently in-use by a number of incumbent and competitive local exchange carriers to provide high-speed access to Internet Service Providers (ISPs) and thus to the Internet. FIG. 15 provides an alternative functional illustration of the elements of such a network. Of particular note, FIG. 15 shows the various protocol stacks in association with the appropriate network elements.

As shown in FIG. 14, a central office (CO) 100 provides plain old telephone service (POTS) and digital subscriber line data service for a number of customers. For purposes of discussion, assume that the equipment at each of the various customer premises 200 connects directly to the CO 100 via twisted pair type copper wiring 300. In an actual implementation, many customers may connect through such wiring to a remote terminal linked to the CO via optical fiber.

At each customer premises 200 in our example, the copper loop 300 carrying both the POTS and ADSL signals connects through a Network Interface Device (NID) 201 placed at the side of the home. A two pair loop is installed from the NID to the location where the ADSL unit 203, typically an ATU-R modem, is located in the home. One pair connects all of the signals on the line 300 from the NID 201 to the ADSL modem 203. Within the ATU-R type modem 203, a passive splitter/combiner type filter segregates the POTS signal and the data signals. The POTS signal is transmitted over the second twisted pair back to the NID 201. The POTS line is then connected to the in-home wiring extensions at the NID 201, for distribution to one or more standard telephone devices 205 in the home.

Within the ATU-R type ADSL modem 203, the downstream coded ADSL signal is demodulated and decoded to an appropriate data interface protocol for connection to the PC 215. The PC 215 or other data device (FIG. 15) also sends data to the ADSL modem 203. The modem 203 modulates the upstream data and transmits appropriate signals over the line 300₁ or 300₂ to the corresponding modem 113₁ or 113₂ in the CO 100 (FIG. 14). The ATU-R interface may support bridging, such that multiple users can share the ADSL modem 203, for two-way data communication through the CO 100.

The lines 300 for the customer premises 200 connect through the main distribution frame (MDF) 101 to a Digital Subscriber Line Access Multiplexer (DSLAM) 111. The DSLAM includes a bank of ADSL terminal units of the type intended for central office applications, identified as ATU-Cs 113. The DSLAM also includes a multiplexer/demultiplexer (MUX) 115.

Within the DSLAM 111, each customer line 300 connects to an assigned ADSL terminal unit 113 in the central office (ATU-C). In the example illustrated, the first customer's line

300₁ connects through the MDF 101 to a first ATU-C 113₁ in the CO 100. The second customer's line 300₂ connects through the MDF 101 to a second ATU-C 113₂ in the CO 100. The ATU-C type ADSL units 113 include appropriate frequency dependent combiner/splitters, for segregating out the voice telephone traffic. Thus each ADSL unit 113 provides a connection for telephone traffic from the associated line 300 to the POTS switch 103.

The ADSL units 113 in the CO (ATU-Cs) essentially act as modulator/demodulators (modems) for sending and receiving data over the subscriber telephone lines 300. On the network side, each of the ATU-Cs 113 connects to the MUX 115. The MUX 115 multiplexes and demultiplexes the upstream and downstream data for the ADSL modems 113 and provides a connection to a high-speed link 119. Through subtending, the MUX 115 may also provide a data concentration for the communications over the link 119.

In a typical implementation, the concentrated data communications utilize a DS-3 link 119. However, because of increasing traffic demands, it is becoming necessary to upgrade the link 119 to SONET optical fiber, such as OC-3 or in some cases even OC-12. The link 119 provides two-way data communication between the central office 100 and a data hub 121. In practice, this is a relatively long or wide area link using expensive interoffice facilities.

On the upstream side, the high-speed interoffice link 119 terminates on an ATM switch 123 for the ADSL data network (ADN). Although only one link 119 appears in the drawing, the asynchronous transfer mode (ATM) switch 123 will typically service a number of DSLAMs 111 in various end offices via similar DS or OC links. The ATM switch 123, in turn, provides a high-speed connection to a gateway router 125 coupled to an ATM cell relay network 129. Typically, the ATM switch 123 will aggregate traffic from a number of such links 119 onto an OC-3 or higher rate SONET link to the router 125. The router 125 and the cell relay network 129 enable transport of ATM cells for the subscribers to and from equipment of one or more Internet Service Providers (ISPs), shown by way of example as a concentrator 131 coupled to the public packet switched network commonly known as the Internet 132.

The illustrated local access type ADN network provides ATM cell transport from a customer premises 200 to the ISP concentrator 131. The ATM cells serve as the layer-2 routing or switching protocol for the lowest level definition of connectivity between two points of the network. Higher level protocols ride within the ATM cells.

The ATU-Rs 203 and the customer premises data equipment 215 connect via an Ethernet coupler. The customers' equipment communicates across the ADSL data network utilizing Ethernet, and the wide area communication involves transport of Internet protocol information typically in TCP/IP frames within Ethernet frames. The Ethernet frames carrying the TCP/IP frames are adapted into ATM cells. Attention is directed to the protocol stacks illustrated in the lower half of FIG. 15.

To efficiently provide cell relay, each customer is assigned an ATM virtual circuit that extends from the ATU-R 203 in the respective customer premises 200 to the gateway router 125. Although it was originally envisioned that ATM would support switched logical channels or virtual circuits, to date, such logical switching has proven impractical to implement and administer. Consequently, current practical ATM networks actually utilize permanent virtual circuits, not switched virtual circuits. For a given subscriber, the carrier therefore provisions an ATM permanent virtual circuit from

the ATU-R 203 to the gateway router 125. The carrier programs one or more nodes along the path of that logical circuit, particularly the DSLAM 111, to regulate traffic on the virtual circuit to the upstream and downstream rates corresponding to the grade of service to which the particular customer subscribers. All data traffic for the subscriber goes over the entire length of the permanent virtual circuit, and most, if not all nodes along that path limit that traffic to the rates of the subscription as defined in the provisioning data.

The virtual circuit may be thought of as a solid pipe. All traffic passes through the entire length of the pipe-like virtual circuit, regardless of how many switches or other nodes the circuit passes through. The layer-2 protocol defining the circuit carries all of the higher level traffic end-to-end. Higher layer protocols are visible only at the ends of the pipe. Hence, any traffic flow processing intended to utilize the higher layers must occur at some point past one end or the other end of the virtual circuit.

The gateway router 125 also terminates permanent virtual circuits through the cell relay network 129 going to/from the ISP concentrators 131. The gateway router 125 aggregates traffic between a number of subscribers and each respective ISP. The ISP equipment 131 typically implements a variation of a point-to-point protocol (PPP) specifically adapted to ride over Ethernet, referred to as "PPP over Ethernet" (PPPoE). The virtual circuits to the ISPs, however, do not have sufficient capacity to simultaneously carry all subscriber traffic at the maximum rates of the customers' subscriptions. The MUX 115, the ATM switch 123, and the gateway router 125 concentrate and regulate the subscriber traffic going to and from the ISPs, typically on some type of "best efforts" basis.

In a typical Internet access service offering, the most expensive service tier provides 7.1 Mbps for downstream communication and 680 kbps for upstream communication. The next grade of service provides 1.6 Mbps for downstream communication and 90 kbps for upstream communication, whereas the lowest tier of service provides 640 kbps for downstream communication and 90 kbps for upstream communication. The maximum grade of service offered to an individual subscriber depends on the rates for which the subscriber's line can qualify, although the subscriber may opt for a lower rate service since the higher-rate service is more expensive.

The approach outlined above relative to FIGS. 14 and 15 works well for Internet access if the traffic relates to web access, file transfers and the like, which do not require guaranteed quality of service. Various segments of the Internet industry, however, are rapidly developing new multimedia services and applications that already are pushing the capabilities of such a network. For example, increasingly, Internet traffic includes a number of types of communication that require a guaranteed quality of service. Voice telephone communication over IP is extremely sensitive to latency and jitter. The permanent virtual circuits provide an unspecified bit rate (UBR) service and do not guarantee any minimal amount of delay or jitter. Also, because the rates are set by subscription, the service tends to be relatively inflexible. Some services, such as multicasting of broadband information from the Internet into the local access ADN for a large number of concurrent users, can quickly overload one or more nodes or critical links of the network, for example the link 119 between the DSLAM 111 and the ATM switch 123 at the hub 121.

Most industry experts propose to increase the services available via the public Internet. However, because the

higher layer protocols are visible only on the Internet side of the virtual circuit "pipe," these services all must be implemented out past the end of the virtual circuit, at least behind the gateway router 129 and most likely in the public network, where it is possible to view and route based on higher level protocols, particularly Internet protocol (IP). Such a migration strategy to implement new services creates severe problems. For example, in the network of FIG. 14, if a customer at premises 200, desired to order a video on demand, the customer would communicate via the assigned permanent virtual circuit and the ISP to a server on the Internet 132. The server would send the video stream back through the Internet 132, the ISP equipment 131, the cell relay network 129 and the virtual circuit from the router 125 to the ATU-R 203 for handoff to a PC or the like at 215. If the rate of the requested video exceeds the customer's subscription rate, the customer could not view the video in real time during the download. Even if the rate of the requested video is below the customer's subscription rate, loading in the Internet or the local access network may impose delays and/or jitter in communication of some segments of the requested video. Assuming that the hub 121 and the links 119 implement a subscriber concentration, ordering of videos or similar broadband files from the Internet 132 quickly consumes the shared resources through the hub 121 and the links 119, reducing the rates of service provided to other customers seeking concurrent Internet access.

It might be possible to increase the capacity of the links 119 and/or the hubs 121; however, this tends to increase the carrier's recurring costs and often makes the overall service(s) of the ADN network economically impractical.

It has also been suggested to provide customers guaranteed quality of services for some portion of their communications, by segregating the traffic carried between the customer premises and the hub 121. This would require assigning a plurality of ATM permanent virtual circuits to each subscriber, one for each different guaranteed level of quality of service and one for all other Internet traffic for the subscriber. Administration and provisioning of one virtual circuit per subscriber is already complicated, and the number of virtual circuits through any given ATM node is limited by current equipment designs. Expanding the number of permanent virtual circuits per subscriber to support multiple QoS tiers of service therefore would be quite expensive, and the management thereof would become a nightmare. To support an increased number of virtual circuits, many having guaranteed QoS requiring some substantial minimum rate at all times, would also require that the operator substantially upgrade the network to increase the end-to-end capacity all the way to the wide area network 132.

Furthermore, to actually receive the desired QoS requires that all elements involved in the communication must guarantee the desired level or quality of service. For communications across the public Internet 132, this means that various nodes and links on the public Internet must be available and capable of providing a guarantee of the desired QoS. In point of fact, few nodes on the public Internet actually support any type of QoS. Hence, even if the ADN supported a desired QoS, most subscribers would not benefit from that service because their communications over the public Internet would have no QoS guarantee, and would suffer from the usual problems of latency and jitter.

Consequently, current deployments of ADSL-based data networks, such as shown in FIGS. 14 and 15 generate many customer complaints. From the customer perspective, the service does not deliver the data rates that the customer pays

for on a consistent basis. The customer typically blames such problems on network equipment failure. In fact, most of the problems already are due to virtual circuit congestion problems, of the kinds outlined above. Essentially, the ADN network is crippled by the unpredictable nature of the service levels that the customers perceive due to congestion on the ADN and on the public Internet.

Also, with this approach, because all of the major service elements are implemented in servers accessible to the Internet, all of the services are subject to severe security risks. Each service provider's server is accessible to virtually any computer coupled for communication via the Internet. This openness is a desirable feature of the public Internet. However, a consequence is that any such server is accessible to and thus subject to attack from any hacker having Internet communications capabilities. Popular services, particularly those generating substantial revenues, become prime targets for attack.

Another area of problems is that the ADN does not offer the carrier any technique for offering its own differentiated service applications. To compete with other service providers, the carrier operating the ADSL-based data network needs to introduce its own multimedia services, for example, its own video services to compete with video services of cable television companies (that offer competing Internet access services). As noted above, however, introduction of a new service, such as true video on demand or broadcast video requires communications via the public Internet 132. This is true even if the carrier operating the network of FIGS. 14 and 15 wanted to initiate its own video service(s).

Hence, there is an ongoing need to improve the architecture and operation of a digital subscriber line data communication network, particularly to facilitate finer gradation of services within the local network. The need, first, is for such a local network to support introduction of services on a 'vertical' basis within the local access network separate and apart from the common forms of Internet traffic, both for commercial differentiation and for increased security. In a related need, the local network needs to support a number of different levels of quality of service (QoS). There also exists a need for upstream traffic to be shaped by customer equipment located at or near the interface between a customer's network and the ADN according to traffic destinations. A similar need also exists for such customer equipment to prioritize and queue the upstream traffic according to QoS metrics mirroring those of the ADN.

SUMMARY OF THE INVENTION

A general objective of the invention is to implement an enhanced digital communication network for subscriber lines that supports vertical introduction of new communication and/or multimedia services.

A further objective is to support multiple levels or grades of quality of service within the access network.

Another objective of the invention relates to improvement of the cost effectiveness of the data network, for example, by reducing the demand for high-capacity interoffice links while increasing the bandwidth available at the network edge for at least some types of services.

A related objective is to provide a technique for introduction of new high-end services near the network edge, from a domain that is more secure and therefore less subject to hacker attacks.

A further objective of the invention is to support QoS and/or local introduction of vertical services, without the need to assign multiple virtual circuits or the like to each subscriber.

Still further objectives of the invention relate to provisioning of service through an access data network. Specifically, it is an objective of the provisioning related concepts to significantly reduce, or completely remove, the errors present in the existing data circuit provisioning process, which includes: manual ordering processes; manual record-keeping; and manual circuit changes at the PSTN frame and the intermediate ADSL frame.

A further objective of the invention is to support customer premises data equipment that have conventional protocol stacks without the need for additional or proprietary shim software in each user device.

A related objective is to support a plurality of different customer premises data equipment that each include a network stack implementing a common communications protocol.

Another objective of the invention is to provide a single logical communications session which multiplexes multiple actual sessions between a customer data equipment and other devices on a local access network or the Internet. A related objective is multiplexing multiple sessions from various customer premises data equipment over a single logical communications session.

A further objective of the invention is to alter data frames received from customer premises data equipment according to the destination network domain of the payload of that data frame and to forward the altered data frame to the ADN.

Another objective of the invention is to enforce access control lists that prevent certain sessions from being established or used between particular customer premises data equipment and particular network destinations.

A further objective of the invention is to support QoS guarantees in the upstream traffic received from customer premises data equipment and forwarded to the ADN.

The preferred embodiments of the invention alleviate many of the above noted problems by providing an intermediate node, typically an enhanced switch, to segregate upstream traffic based on analysis of the type of communication. This analysis utilizes protocol information contained in each communication, for a protocol higher than the switching protocol, that is to say higher than a protocol used to define the customer's logical circuit. In an implementation utilizing ATM, for example, the logical circuit is a virtual circuit, and the node examines the protocol information for layers above the ATM layer. One type of traffic remains on the virtual circuit, whereas other traffic is handed off to a vertical services domain. The node also provides a point to aggregate traffic from the from the vertical services domain with other traffic on the subscriber's logical circuit, for transport to the customer premises equipment.

To this end, the preferred embodiments use an ATM switch having routing/processing capabilities at the higher layer, for example at the layer-3 protocol or above, in close proximity to a DLSAM. The links between the DLSAM and this switch can be of any desired high capacity because they are short and therefore relatively low in cost. Consequently, the DLSAM and the new ATM switch can support relatively high bandwidth from that node to the customer premises. To utilize the increased bandwidth and support new services, the modems on the opposite ends of the digital subscriber line negotiate and operate at the maximum rate that the line conditions will permit.

The ATM switch essentially subdivides the traffic associated with each subscriber line. One branch goes to a gateway router and hence to one or more ISP(s) at the rate corresponding to the Internet access subscription. It may be

helpful to consider this as long distance or wide area traffic for the subscriber. The other branch is for local traffic, to and from the locally connected vertical services domain. The interconnection to the vertical services domain supports QoS and introduction of vertical services not easily provided from the public Internet, such as video on demand, multicasting, and voice over IP. The vertical services domain is relatively secure since it is not accessible from the public Internet.

In operation, the access network will still support a logical circuit in the form of a virtual circuit to the gateway router for each customer, for example in the form of an ATM permanent virtual circuit. That circuit is provisioned for the subscriber's desired grade or quality of Internet access service. The subscriber line, however, supports at least the same and often a higher rate service, for example via rate-adaptive ADSL communication over a twisted wire line. In the upstream direction, the ATM switch examines at least one aspect of each data transmission relating to a logically higher level of protocol, e.g. in a layer 2 protocol encapsulated in ATM, or at layer 3, layer 4, or higher. From the higher level information, the switch determines the type of transmission and segregates the upstream transmissions on the subscriber's virtual circuit. One type of transmission continues on the virtual circuit, e.g. for Internet transport. Any and all other types, however, go to the vertical services domain. In the downstream direction, the ATM switch aggregates any communications coming from the vertical services domain together with downstream transmissions on the virtual circuit from the Internet.

The vertical services domain also represents a communication network. The vertical services domain, however, preferably takes the form of a data network optimized for local transport of vertically injected services, that is to say local data traffic. In view of its local nature, it is easier and more cost effective to provide high bandwidth services. The vertical services network, for example, could take the form of a giga-bit Ethernet type local area network. Also, it is easier to adapt the vertical services network to support service level agreements with customers with regard to quality of service. In many cases, it actually is sufficient to support QoS on the one hop through the ATM switch, itself.

To support the QoS requirements, a feature of the preferred embodiments involves certain queuing and tagging operations within the ATM switch. Essentially, the switch will maintain two or more queues for each permanent virtual circuit. The switch distinguishes the queues based on importance. As the switch receives cell transmissions for transport over the virtual circuit to the customer premises, the switch will internally tag each cell as to its importance level and place the cell in the appropriate queue. The switch may implement any one of a number of different algorithms to select and transmit cells from the various queues. The particular algorithm is selected to implement QoS in conformance with the subscriber's service level agreement with the carrier and/or agreements between the carrier and the vertical services providers.

Within the one virtual circuit assigned to the individual subscriber, the invention actually provides multiple tiers of service, preferably with multiple levels of QoS. Also, at different sections along the virtual circuit "pipe," the network provides different levels of rate shaping. All layers and all services are available at the home, but different services receive different treatments in the network conforming to the different levels of QoS. The inventive approach, however, does not require each subscriber to have multiple virtual circuits.

Services provided on the vertical services domain appear as IP data services. Virtually any communication service may utilize the vertical services network and through it to gain access to the carrier's local customer base, simply by providing an IP interface for coupling to the vertical services network. For example, it is a simple matter to connect any digital source of broadcast audio or video information, such as a direct satellite broadcast receiver system similar to those used today in residential applications, through an IP interface. Such a broadcast source and interface can provide the full range of received video services, over the vertical services network. The access data network may distribute the video programming to a number of access switches within a local geographic area. The switch provides an optimum point for frame or cell replication for multicasting services. Hence, in our video example, the switch replicates and distributes frames for the broadcast service over the digital subscriber line circuits to customers desiring to view the programming.

An aspect of the present invention relates to a CPE and associated software and methodologies for separating a protocol stack shim software from the customer devices, or customer premises data equipment, using the network services. According to this aspect of the invention, a CPE is provided that receives data from the devices according to a common encapsulation scheme, determines the encapsulation scheme needed in order for that data to be properly routed in the access network, and then encapsulates the data into the appropriate ethertype frame. Typically, Internet-bound frames are encapsulated using PPPoE so they pass through the VSI switch, while frames destined for the vertical services domain are encapsulated using another ethertype to allow the VSI switch to properly route them. A number of benefits arise from locating the PPPoE software on the CPE, including, for example, increased security control, PPPoE proxy services, and implementation of QoS in the upstream direction.

A further aspect of the invention relates to unique software for implementing, for example, the frame examining, destination determining, frame altering, security enforcing, and QoS prioritizing functions of the CPE. A software product, in accord with this aspect, includes at least one machine readable medium and programming code, carried by that medium. In a preferred embodiment, the code includes several cooperating applications which may reside in separate media within the CPE.

A computer readable medium, as used herein, may be any physical element or carrier wave, which can bear instructions or code for performing a sequence of steps in a machine readable form. Examples of physical forms of such media include floppy disks, flexible disks, hard disks, magnetic tape, any other magnetic medium, a CD-ROM, any other optical medium, a RAM, a ROM, a PROM, an EPROM, a FLASH-EPROM, any other memory chip or cartridge, as well as media bearing the software in a scanable format. A carrier wave type of medium is any type of signal that may carry digital information representative of the instructions or code for performing the sequence of steps. Such a carrier wave may be received via a wireline or fiber-optic network, via a modem, or as a radio-frequency or infrared signal, or any other type of signal which a computer or the like may receive and decode.

Additional objects, advantages and novel features of the invention will be set forth in part in the description which follows, and in part will become apparent to those skilled in the art upon examination of the following and the accompanying drawings or may be learned by practice of the

invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing figures depict preferred embodiments of the present invention by way of example, not by way of limitations. In the figures, like reference numerals refer to the same or similar elements.

FIG. 1 is a functional block diagram of a digital subscriber line data network supporting enhanced services in accord with the inventive concepts.

FIG. 2 is a slightly modified functional block diagram of network of FIG. 1, illustrating the protocol stacks used in the various network elements.

FIG. 3 is a functional block diagram of the network showing the service level agreements (SLAs) for which the network provides appropriate QoS.

FIG. 4 is a logical diagram of the functional elements of an L3/4 switch, for use in the inventive network of FIGS. 1-3.

FIG. 5 is a block diagram of a modified portion of the network, useful in explaining migration to other types of physical transport and switching/routing protocols.

FIG. 6 is a block diagram of a portion of the network of FIG. 5, showing the interconnection thereof with the wide area network and the local vertical services domain.

FIG. 7 is a block diagram of the network similar to those of FIGS. 1 and 2, but showing details with regard to certain elements thereof enabling an automated service selection and provisioning procedure in accord with a further aspect of the invention.

FIG. 8 is a flow-chart illustrating the steps of an example of the automated service selection and provisioning procedure.

FIG. 9 is a simplified diagram of the network of FIGS. 1 and 2 but showing customer premises equipment (CPE) according to an alternative embodiment of the present invention.

FIGS. 10 and 11 illustrate a detailed schematic and logical view, respectively, of the features within the CPE of FIG. 9.

FIG. 12 is a flow-chart illustrating the steps of an example of the CPE encapsulating frames according to the intended network destination of the frame.

FIG. 13 is a flowchart illustrating the steps of an example of automatically programming the CPE according to the services used by a customer.

FIG. 14 a block diagram of a prior art asymmetrical digital subscriber line data network.

FIG. 15 is a slightly modified functional block diagram of the prior art network illustrating the protocol stacks used in the various network elements.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

The inventive network architecture introduces QoS into the ADN, in a manner that enables the delivery of sophisticated and demanding IP-based services to subscribers. The architecture does not affect existing Internet tiers of service such that the promised rates for such access appear the same as offered today. Also, the new architecture is cost-effective in terms of initial costs, build-out, and ongoing operations. The architecture utilizes an access switch or router capable

of examining and selectively forwarding packets based on a relatively higher layer of the protocol stack, that is to say based on information encapsulated within the layer-2 information utilized as the lowest level definition of connectivity through the network. The access switch enables segregation of upstream traffic by communication type and downstream aggregation of wide area traffic together with traffic from a local vertical services domain.

In accord with the invention, the access switch examines the higher-level protocol information in the upstream communications to segregate traffic into two or more streams based on traffic type. A logical circuit provisioned for the subscriber extends from the customer premises through the switch to a node providing service to the packet switched network, typically on the Internet. The provisioning of this circuit defines a contiguous connectivity for the logical circuit, in the layer-2 protocol utilized by the network. Higher level protocols ride within this particular layer-2 protocol, including some protocols that are often considered themselves to be layer-2 protocols.

The analysis of upstream packets to determine higher-level type enables segregation of the upstream traffic into two or more upstream flows. For example, this allows the switch in the preferred embodiment to keep traffic bound for the packet switched internetwork on the logical circuit but route all other traffic onto another network, in this case a local network for vertical services. In the preferred embodiment, from the access switch or router to the packet switched network, the provisioning for the logical circuit limits the rate(s) of communication to those defined by the grade of service to which the customer subscribes. From the customer premises to the switch, however, the communications run at the optimum rates that the facilities can physically support, e.g. the maximum rates that the ADSL modems or the like can adaptively establish for the particular subscriber's line.

In the downstream direction, the switch aggregates traffic for each subscriber. The switch receives the rate-limited traffic from the packet switched network, on the subscriber's logical circuit. The switch also receives any downstream traffic intended for the subscriber, from the vertical services network. The switch combines this traffic and sends the combined communications downstream over the subscriber's logical circuit to the customer premises, at the optimum downstream rate that the subscriber's facilities can support.

The functionality of the customer premises data equipment that formats upstream frames according to a frame's destination within the ADN can be performed by a separate device positioned between the customer premises data equipment and the ADN. The term "separate device" simply means the device is distinct from the customer premises data equipment; however, this device could be a physical part of some other device, for example, the ATU-R. This separate device can segregate traffic into different data types, according to destinations within the ADN, with the upstream switch or router still performing forwarding of the traffic according to its type. This separate device can act as a session proxy and also enforce other traffic rule-sets such as security access control lists and QoS metrics that mirror those of the ADN.

FIG. 1 provides a high-level functional illustration of an exemplary digital subscriber line network, specifically an ADSL data network 10, implementing the various concepts of the present invention. FIG. 2 provides an alternative functional illustration of the elements of such a network. Of particular note, FIG. 2 shows the various protocol stacks

13

associated with the appropriate network elements that utilize those stacks. The end-user may be a single PC user or a small business or a residential LAN user. The data equipment of such users typically includes servers and PCs and may include a variety of other devices, such as fax machines, televisions, recorders and remote controlled appliances, having data communication capabilities.

The customer access link comprises an xDSL twisted pair, although those skilled in the art will recognize that the invention is readily adaptable to networks using other types of links to the subscriber premises. In the illustrated embodiment, the network 10 supports ADSL, which the carrier may offer in grades supporting 640 kbps, 1.6 Mbps or 7.1 Mbps (downstream) rates for Internet access. The actual communications over the DSL loops, however, run adaptively at the maximum rates that the line conditions allow.

The ADSL-based local access data network or "ADN" 10 provides access to two different network domains for communication services. The two network domains are logically separate. In most implementations, the first domain may be considered as a long distance or wide area domain, whereas the second domain is a local network domain. In the illustrated example, the ADN 10 provides access to a first domain in the form of a wide area internetwork, such as the public Internet, corporate local area networks (LANs), and the like, represented by the network cloud 11 for the ISPs. The high speeds available through the local network 10 enable a wide range of communications, for example, of text data, of video data, for multimedia, for web browsing, of transfers of files, for database searching, and the like via the network(s) 11.

In accord with the invention, the ADSL-based local access network 10 also offers access to a wide variety of other IP-based services through a local data network 13 serving as the vertical services domain (VSD). The vertical services typically are high-end services requiring certain QoS levels and often having a certain local characteristic. Examples of the vertical services are discussed in more detail later.

The vertical services network offers an efficient domain from which the carrier can locally inject high-end services and/or services of other local providers. Because the vertical services domain is separate from the public Internet, equipment providing the vertical services is subject to attacks directly from the public Internet.

As shown in FIGS. 1 and 2, a central office (CO) 15 comprises one or more DSLAMs 17 and L3/4 ATM switch 19. Elements of the CO 15 providing plain old telephone service (POTS) have been omitted for simplicity of illustration, since they are generally similar to those shown in FIG. 9.

The switch 19 is designated as an "L3/4" switch here as a matter of convenience, to illustrate that the switch 19 has the capability to make selective packet forwarding decisions based on protocol information at some level that is above the L2 level that the switch normally utilizes to define or establish logical circuit connectivity. It will be recognized, however, that some of the protocols, although higher than the ATM type level 2 protocol used by the preferred switch are themselves often thought of as level 2 protocols even though they are above or encapsulated in the ATM type level 2 information. Also, decisions as to the selective forwarding may be made in response to monitoring of any level of the protocol stack above the L2 level that the switch normally utilizes to define or establish logical circuit connectivity, for

14

example from any level above ATM all the way up to the L7 application layer.

Returning to the discussion of FIGS. 1 and 2, for purposes of this discussion, assume that the equipment at the various customer premises connect directly to the CO 15 via twisted pair type copper wiring 21. In an actual implementation, many customers may connect through such wiring to a remote terminal linked to the CO 15 via optical fiber. Other hardwired, optical or wireless implementations of the digital subscriber lines are discussed later. In the illustrated embodiment, each line 21 from a customer premises connects to an ATU-C within one of the DSLAMs 17.

On the customer premises side, the digital subscriber line circuit 21 connects to an ADSL terminal unit (remote) or ATU-R 23. The ATU-R 23 is a modulator/demodulator (modem) for communicating over a twisted wire pair type line 21, in accord with the ADSL protocols. The ATU-R in turn connects to customer premises equipment, shown by way of example as a PC 25 at each location (FIGS. 1 and 2). Those skilled in the art will recognize that the customer premises equipment 25 may include a wide range of other types of devices having data communications capabilities (see e.g., FIG. 3).

The ADSL user's normal telephone equipment (not shown) also connects to the line 21, either directly or through a frequency combiner/splitter, which often is incorporated in the ATU-R. The normal telephone signals are split off at both ends of the line and processed in the normal manner.

For digital data communication purposes, the ATU-C and ATU-R modem units create at least two logical channels in the frequency spectrum above that used for the normal telephone traffic. One of these channels is a medium speed duplex channel; the other is a high-speed downstream only channel. Such modems may implement either one of two techniques for dividing the usable bandwidth of the telephone line to provide these channels. One approach is to divide the usable bandwidth of a twisted wire pair telephone line by frequency, that is to say by Frequency Division Multiplexing (FDM). The other approach uses Echo Cancellation. FDM uses one frequency band for upstream data and another frequency band for downstream data. The downstream path is then divided by time division multiplexing signals into one or more high-speed channels and one or more low speed channels. The upstream path also may be time-division multiplexed into corresponding low speed channels. With echo Cancellation, the upstream band and downstream band substantially overlap. The modems separate the upstream and downstream signals by means of local echo cancellors, in a manner similar to that used in V.32 and V.34 modems.

The DSL modems may use a number of different modulation techniques to physically transport digital data streams. A number of implementations of the modems have used carrierless amplitude phase (CAP) modulation. Most current xDSL modems, however, utilize a discrete multi-tone (DMT) approach.

Returning to the discussion of the CO 11, the structure and operation of each DSLAM 17 is essentially the same as those of the DSLAM 111 in the embodiment of FIG. 9, except that the control functionality of the DSLAM 17 is somewhat different. The DSLAM 17 controls the ATU-Cs to implement a rate-adaptive ADSL service, to adapt operations so as to maximize data rates for the communications over the individual subscriber lines. Essentially, the ATU-Cs and ATU-Rs signal each other over the lines to synchronize

their modes of operation at parameter settings, which achieve optimum data throughput. Also, the DSLAM 17 does not need to monitor or limit the line rates, but instead relies on the rate-adaptive control algorithm to maximize the rates achieved over the ADSL circuits or provide rate-shaping for the ATM virtual circuits. Other network elements limit rates, where necessary.

The L3/4 ATM switch 19 is co-located with the DSLAMs 17, within one central office 15. As a result, it is practical to connect the multiplexer within each of the DSLAMs 17 over a high-speed data link directly to an appropriate port of the ATM switch 19. Because these links are short, there is little or no cost imposed when implementing such links using wideband equipment. By itself, the co-location of the L3/4 ATM switch 19 with the DSLAM(s) 17 does not increase bandwidth. Rather, it makes increased bandwidth at the network edge economically feasible, due to proximity. Co-location removes the requirement to purchase expensive wide area transport (the SONET ring) to increase bandwidth. In particular, the direct OC3/OC12 connections between the 20 DSLAM 17 and the L3/4 ATM switch 19 do not incur any recurring tariff expenses.

The ATM switch 19 connects through a SONET ring 27 to a gateway router 29 providing ATM transport through a cell relay network 30 (FIG. 2) to the ISPs shown at network 11 in the drawings. Most of the ISPs will utilize a concentrator or other equipment as their point of presence for Internet access (FIG. 2). In the preferred embodiment, the equipment 31 provides a point-to-point protocol (PPP) interface designed for transport over Ethernet (PPPoE). The ATM switch 19 also provides a connection to the local implementation of the VSD network 13, for example via a giga-bit Ethernet port to a switch or other local network elements 18.

The illustrated local access type ADN network 10 provides ATM cell transport from the customer premises to the ISP network(s) 11. The ATM cells serve as the layer-2 protocol for defining contiguous switched connectivity. Higher level routing protocols, such as Ethernet and TCP/IP frames, ride within the ATM cells. Services of different types utilize different protocols at one or more layers above the ATM cell layer. In the preferred embodiments, all communications utilize Ethernet. However, communications to and from the ISPs use the noted PPPoE type Ethernet protocol. In contrast, communications to and from the vertical services domain use one or more of the other Ether-type protocols.

To efficiently provide cell relay, each customer is assigned a virtual circuit that extends from the ATU-R 23 in the respective customer premises to the gateway router 29. This logical circuit is defined at the layer-2 protocol level. The present implementations implement this logical communication circuit as an ATM permanent virtual circuit, although the inventive concepts may apply to other types of logical circuits or channels.

The gateway router 29 is the communication node of the access network 10 providing access to the wide area IP packet networks, of corporations or more often of Internet Service providers. The gateway router 29 terminates permanent virtual circuits through the cell relay network 30, from the equipment 31 of each such wide area packet network provider 11. The gateway router 29 also terminates the permanent virtual circuits from the subscribers through the data network 10. For communication with a selected ISP network 11, for example, the gateway router 29 routes cells from the permanent virtual circuit from the subscriber through to the permanent virtual circuit of the selected ISP

network 11. In the opposite direction, the gateway router 29 routes cells from the permanent virtual circuit from the selected ISP network 11 through to the permanent virtual circuit of the particular subscriber.

For the leg of the subscriber's logical circuit, extending from the L3/4 ATM switch 19 through the gateway router 29, the carrier programs one or more nodes along the path behind the DSLAMs 17, to regulate traffic on the virtual circuit to the rate corresponding to the grade of Internet access service to which the particular customer subscribes. In the preferred embodiment, at least one such node performing this rate shaping function is the L3/4 ATM switch 19. All traffic going to and from the ISP network(s) 11 therefore is still limited to the rates defined in the service level agreement (SLA) for Internet access that the carrier has with the particular customer.

The portion of the virtual circuit extending between the ATM switch 19 and the ATU-R 23, however, is not rate limited but instead runs at the maximum rate that the line will support using the rate-adaptive ADSL modem operation. In most cases, the rate-adaptive ADSL modem operation will support rates substantially higher than the subscription rate for Internet access service.

The L3/4 ATM switch 19 also provides the interconnection to the subscriber's virtual circuit for insertion of downstream traffic from the vertical services domain 13 and separation of upstream traffic from the subscriber's virtual circuit going to the vertical services domain 13. In accord with the invention, decisions as to whether upstream traffic 25 is destined for the vertical services domain 13 or should remain on the subscriber's virtual circuit going through the gateway router 29 and the cell relay network 30 to the ISPs 11 is based on an analysis of traffic type. The traffic type analysis 30 relies on protocol information contained in the 35 communications, which relates to layers of the protocol stack that are higher than the layer-2 switching protocol, in this case above the ATM layer.

As shown in FIG. 2, traffic destined for an ISP 11 utilizes 40 a variation of a point to point protocol (PPP) intended to run on top of Ethernet, referred to as PPP over Ethernet or "PPPoE." A 'type' indicator contained within the Ethernet frames identifies the PPPoE protocol. In contrast, traffic 45 going to and from the vertical services domain utilizes other 'types' of Ethernet protocol. All traffic to and from the customer premises uses Ethernet frames carried within ATM cells.

The switch 19 therefore routes a subscriber's traffic going to and from an ISP 11, upon detection of the PPPoE indicator 50 in the level 3 data contained within the Ethernet cells. This traffic will also utilize public IP addressing. In contrast, the ATM switch 19 routes a subscriber's traffic going to and from the vertical services domain, upon detection of any other type of Ethernet protocol at level 3 or above in the 55 protocol stack. The IP addressing in the vertical services domain 13 utilizes private-IP addresses, for example, as administered with a DHCP server (not shown) coupled to the network cloud 33. Although shown separately, the cloud 33 may be implemented as a portion of the network providing the physical elements of the vertical services domain. The portion 33, however, would typically be a logically separate domain that the carrier controls and restricts for its own 60 network administration use.

FIG. 3 depicts the logical division of the subscriber's traffic, as implemented at the ATM switch 19 in accord with the invention. As shown, the network 10 provides a logical 65 "pipe" or circuit 35 extending to the networks 11 of one or

more of the ISPs, for an Internet access application. The ATM switch 19 (FIG. 1) preferably performs a rate shaping or control function. The leg 35 of the subscriber's traffic extending to the ISP 11 provides upstream and downstream communication rates conforming to a service level agreement (SLA) applicable to the subscriber's Internet access application. As such, the communications over the subscriber's logical circuit, extending from the switch to the ISP, provide a first level of QoS. To the subscriber, service over the leg 35 appears the same as a subscriber selected grade of Internet access service as provided by older ADN architectures. FIG. 3 illustrates chat rooms, web surfing and e-mail as examples of services an ISP might offer through the Internet Application SLA circuit 35 and the attendant portion of the subscriber's assigned logical circuit through the access network.

The network 10 also supports communications over one or more logical application paths 36 to local applications 37 hosted in the vertical services domain. Assuming that a subscriber with various equipment 25 also subscribes or otherwise participates in one or more of the vertical services, the local carrier (e.g. Bell Atlantic in FIG. 3) offers a corresponding number of additional application SLAs with the customer. Each SLA for a vertical service may specify QoS parameters for the particular application, such as rate/bandwidth, latency, jitter, packet loss, packet sequence, security and/or availability. Examples of such applications hosted in the carrier's vertical services domain 37 include the illustrated voice over IP service shown as a V/IP gateway, as well as video services and some caching for high volume local web services. Communications for such applications utilize the one or more paths 36.

The network of FIGS. 1 to 3 also supports closed or private user work groups or virtual local area networks (VLANs). VLANs, for example, may be implemented as a service hosted through the vertical services network 13. All traffic from customer premises belonging to one of the

and their shared resources (servers, printers, etc.), that may be physically separated from each other. VLAN groupings can provide privacy and security to their members while enabling "broadcast domains" whereby broadcast traffic is kept logically "inside" the VLAN.

The present invention also supports segregation and aggregation of traffic for three or more domains, based on the higher-level traffic type analysis. An alternative implementation for closed user group services therefore might actually provide a third domain for such services. PPPoE traffic would go to the concentrator equipment 31, as discussed above. The switch 19 would route the upstream transmission frames bearing a VLAN Ethertype indicator to the alternate network serving as the VLAN service domain. That domain would process VLAN communications essentially as done in a normal switched Ethernet type network. Upstream transmissions that bear any other type of Ether-type indicator would go to the vertical services network 13, as in the earlier examples.

A feature of the switch, in accord with the invention, is that it prioritizes traffic for each customer to support QoS for the various services as required by service level agreements (SLAs) between the customer and the carrier. In this regard, one implementation of the L3/4 ATM switch 19 performs queuing and tagging operations in accord with the desired prioritization. The switch will maintain two or more queues for each subscriber's permanent virtual circuit. The switch distinguishes the queues based on importance or priority. As the switch receives cell transmissions for transport over the virtual circuit to the customer premises, the switch will internally tag each cell as to its importance level and place each cell in the appropriate queue based on the tag.

The tagging and prioritization may be based on traffic type or 'Type of Service' (ToS). Table 1 illustrates one example of the possible ToS levels that may be assigned to different communications.

TABLE 1

Relative Priority	ToS Value	AR Queuing	Customer Traffic Encapsulated TOS	Internal BA Mgmt Traffic Rewritten TOS
Critical Management Future	0	WFQ (Control 25%)		OSPF, SNMP, ICMP, BGP
Real Time Interactive IP Application Control	1	WFQ (High 40%)	Port numbers identified	
One Way Streaming Media	2	WFQ (Medium 30%)	ICMP, IGMP, EGP, DNS, H.323 signaling, BGP, SIP, Microsoft Media Player Streaming Media Control, RTSP	IGMP, RADIUS
One Way Batch Unknown	3	WFQ (Low 5%)	UDP (ports 1024+)	
Non time sensitive	4		HTTP, HTTPS, SNMP, Telnet	
	5			
	6		Other	Other
	7		FTP, TFTP, SMTP	

VLANs would include a VLAN Ethertype indicator. Since the frames would not be PPPoE type Ethernet frames, the switch 19 would route the upstream transmission to the vertical services network 13. VLAN frames also carry a VLAN identifier. The nodes of the network 13 transport the packets for the VLAN members only to resources that are members of the identified VLAN. In this manner, the capability exists for creating logical workgroups of users

The access switch 19 will examine the content of each communication and determine an appropriate ToS level, for example in accord with the table above. Based on the ToS level, the switch will add a tag to the cell(s) as part of its internal processing. Using the ToS tags, the switch will place each of the cells for a given subscriber into a corresponding one of a plurality of queues that the switch maintains for the subscriber's traffic.

The switch may implement any one of a number of different queue servicing algorithms to select and transmit cells from the various queues. For example, the switch 19 may implement one of several statistical algorithms, equal queuing, weighted queuing, priority selection from queues, etc. The particular algorithm is selected to implement QoS in conformance with the subscriber's service level agreements (SLAs) with the carrier. In most cases, particularly for service applications from the vertical services domain, the switch 19 will not normally drop any cells or packets. In the rare event that the switch 19 becomes congested, any dropping of cells is based on the priority level assigned to the frame, i.e., lowest priority first. Also, if the switch ever drops cells, it drops all cells for an effected lowest priority frame from the relevant queue.

The ability to prioritize traffic across the inserted streams and the PPPoE stream enables the operator to control flows through the ADN 10 so that the local access facility is not overwhelmed with content which exceeds its physical (rate adaptive) limitations. For example, the queuing rules preferably ensure that the 'proper' applications (based on insertion device based rules) obtain access to the limited rate adaptive bandwidth available on any given subscriber's line. Also, the insertion point, switch 19, will usually sit behind the media conversion point (e.g., the DSLAM 17). An OC3 or other facility between the switch 19 and the DSLAM 17 also could become congested. Preferably, the switch 19 or other element at the insertion point queues the traffic in such a manner that no downstream facility (OC3) limitations (which are independent of the rate adaptive DSL loop limitations) will result in packets being dropped.

The queuing will be done based on customer and network provider determined rules so that contention for the facilities facing the subscriber will be addressed via the dropping of the appropriate packets. That way an inserted video stream doesn't overwhelm a PPPoE or Voice stream (due to facility limitations). Among others, appropriate industry understood methods for accomplishing this queuing control include Weighted Fair Queuing (WFQ), Priority (PQ) Queuing, and Weighted Random Early Discard (WRED).

Also, the ability of the switch 19 to examine higher level information provides other advantages in network operations. For example, the switch can implement sophisticated filters on the higher level information, e.g., to provide security. As another example, the switch preferably performs measuring and monitoring to determine what if any packets get dropped (based on the physical rate adaptive limitations), and generates appropriate reports to an external operations system (not shown).

The introduction of the L3/4 ATM switch 19 in proximity to the DSLAM(s) 17 also provides benefits in terms of operation of the gateway router 29. Due to the end-to-end use of the Unspecified Bit Rate (UBR) PVCs, the gateway router interface to the cell relay network 30 has been engineered to support a maximum of 2000–4000 PVCs (end users). This is essentially an over-provisioning of bandwidth that probabilistically avoids service degradation that could result from simultaneous demand for bandwidth. The ability of the L3/4 ATM switch 19 to perform QoS and rate shaping essentially reduces or ever removes this concern, because it significantly reduces the risk that the gateway router 29 will become a bottleneck. As a result, the ADN 10 can increase bandwidth efficiencies for this interface. Further, the capacity through the gateway router 29 need not be upgraded as often to support demand for increased bandwidth associated with new bandwidth-intensive services, since many such services are now introduced through the vertical services domain 13 and the L3/4 ATM switch 19.

To fully understand an exemplary implementation of the various inventive concepts, it may be helpful to consider an ATM-based embodiment of the L3/4 switch 19. FIG. 4 is a block diagram of the elements and functions of such a preferred embodiment of the switch 19.

The preferred embodiments utilize Ethernet framing. As shown in the drawing, the switch 19 includes an Ethernet interface 41, an ATM interface 42 and an associated physical interface 43 facing toward the subscribers. In an embodiment for use in the network of FIGS. 1 and 2, the physical interface might take the form of one or more OC-3 or OC-12 links to the DSLAMs 17. These links carry all ATM cell traffic going to and from the DSLAMs and hence to and from the customer equipment served through the particular switch 19.

The switch 19 also includes an Ethernet interface 44, an ATM interface 45 and associated physical interface 46 facing toward the gateway router 29 and hence the ISPs 11. The physical interface 46 might take the form of one or more OC-12 or OC-48 links to the gateway router 29. These links carry all ATM cell traffic going to and from the ISPs or other wide area inter-networks 11. For these communications, the Ethernet interface 44 passes through PPPoE traffic, as specified by the Ethertype indicator in the cells transporting the relevant frame segments.

Facing the vertical services domain, the switch 19 includes an Ethernet interface 47 and a physical interface 48. These interfaces conform to the particular network utilized by the carrier for the vertical services domain, such as giga-bit Ethernet over wire or optical links.

The switch fabric 49 performs the physical switching of data along various paths through the switch 19, in response to instructions from a programmed routing controller 50. FIG. 4 also shows the communications flow through the switch, for each subscriber. The switch 19 also implements a Decision Point 51, shown for example within the Ethernet interface processing 41 on the subscriber facing side. At that point, the PPPoE traffic is separated from all other traffic. From that point, the PPPoE Flow 52 for each subscriber extends as a portion of the subscriber's ATM virtual circuit, facing the cell relay network and hence the ISPs 11. The PPPoE Flow 52 contains Ethernet frames that are of PPPoE Ethertype. Facing towards the subscriber premises, the switch 19 implements an Aggregate Flow path 53, in the form of another portion of the ATM virtual circuit, which contains all ingress/egress subscriber traffic. The switch implements a Generic Path 54 extending through the interfaces to the vertical services network. This path 54 carries all traffic other than PPPoE.

In this example, the switch 19 implements the Decision Point 51 based on recognition of the Ethertype indicator, which is above the layer-2 ATM cell routing information. However, the switch may implement the Decision Point 51 based on still higher-level protocol information. Also, those skilled in the art will recognize that the concepts of the present invention are applicable in networks using different protocol stacks, for example, based on native IP.

In a preferred embodiment, the Ethernet and ATM interfaces 41 and 42 and the Ethernet and ATM interfaces 44 and 45 implement segmentation and reassemble (SAR) functions, essentially providing two-way conversions between ATM cell format and Ethernet frame format. Segmentation involves dividing an Ethernet frame into a number of 48-byte blocks and adding ATM headers to the blocks to form a corresponding number of ATM cells. Any blocks that do not include a complete 48-byte payload are padded

as necessary. Reassembly entails receiving and buffering ATM cells until it is recognized that a complete frame has been received. The ATM headers of the cells and any padding are stripped, and the payload data is reassembled into the form of an Ethernet frame.

In such an embodiment of the switch 19, the decision point 51 determines how to selectively forward the Ethernet frame information taken from a particular series of upstream ATM cells based on the Ethernet information taken from the ATM cell payloads, for example, by examining the frame header and recognizing the particular EtherType indicator. Internally, the actual switch fabric 49 for such an embodiment of the switch 19 would comprise an Ethernet switch, even though to other elements of the ADN network 10 the switch 19 appears to perform an ATM switching function.

Those skilled in the art will recognize however, that the decision and switch fabric may be implemented in other ways. For example, a series of cells corresponding to an Ethernet frame could be buffered and the payloads examined just to recognize and identify the EtherType indicator, without a complete reassemble of the Ethernet frame. This later implementation therefore could utilize an ATM cell-based switch fabric.

From the discussion above, it should already be apparent that certain aspects of the invention relate to setting up logical communication circuits at a relatively low protocol layer corresponding to switching or routing functions and then segregating traffic by distinguishing communication type using higher level protocol information. To insure full understanding on these points, it may be helpful to consider the protocol layer definitions, with particular reference to the illustration of the preferred layers in FIG. 2. The International Standards Organization (ISO) Open Systems Interconnection (OSI) reference model specifies a hierarchy of protocol layers and defines the function of each layer in the network.

The lowest layer defined by the OSI model is the physical layer (L1). This layer provides transmission of raw data bits over the physical communication channel through the particular network. For example, on the subscriber lines in the preferred embodiment, the physical layer (L1) uses ADSL. Within the customer premises, communications use an Ethernet physical layer (L1), such as 10Base-T. Upstream network elements may use DS3 at some points, but most use SONET, for example OC-3 or OC-12 physical layer transport. Attention is directed to the lower half of the diagram in FIG. 2, which depicts the various protocol stacks throughout the network 10.

The layer defined by the OSI model next to the physical layer is the data link layer (L2). The data link layer transforms the physical layer, which interfaces directly with the channel medium, into a communication link that appears error-free to the next layer above, known as the network layer (L3). The data link layer performs such functions as structuring data into packets or frames, and attaching control information to the packets or frames, such as checksums for error detection, and packet numbers. In the network 10, the data link layer (L2) is used to define certain switching functions through the network. The network layer (L3) provides capabilities required to control connections between end systems through the network, e.g., set-up and tear-down of connections.

The preferred embodiments utilize ATM cell transport as the lowest element of the data link layer (L2), for example to define the connectivity extending from the ATU-Rs 23 through the ADN network 10 to the ISP or corporate

networks 11. Subscriber virtual circuits are provisioned at the ATM cell layer, that is to say at the data link layer (L2). Similarly ISP virtual circuits are provisioned at this ATM data link layer (L2), from the gateway router 29 through the cell relay network 30 to the ISP access concentrators 31. The ATM protocol therefore is the layer-2 (L2) protocol used to define the logical connectivity from the subscriber premises to the gateway router 29. The ATM protocol also is the layer-2 (L2) protocol used to define the logical connectivity from the gateway router 29 to the ISP concentrators 31.

For purposes of this discussion, higher level protocols are protocols that ride on or are encapsulated within the particular layer-2 protocol, that is to say in the payloads of the ATM cells in the preferred embodiment. Such higher level protocols include some protocols, which are often considered themselves to be level-2 protocols, where they are transported within ATM cells. The preferred embodiments use Ethernet, a local area network protocol above the ATM portion of the L2 layer. Technically, the Ethernet protocol may be considered as another L2 layer protocol. However, because it is segmented and encapsulated into the payloads of the ATM cells, the Ethernet protocol information actually is a higher level protocol information above the specific level-2 protocol (ATM) that defines the normal connectivity through the ADN network 10.

In the OSI model, a transport layer protocol (L4) runs above the network layer. The transport layer provides control of data transfer between end systems. Above the transport layer, a session layer (L5) is responsible for establishing and managing communication between presentation entities. For example, the session layer determines which entity communicates at a given time and establishes any necessary synchronization between the entities. Above the session layer, a presentation layer (L6) serves to represent information transferred between applications in a manner that preserves its meaning (semantics) while resolving differences in the actual representation (syntax). A protocol (L7) that is specific to the actual application that utilizes the information communicated runs at the top of the protocol stack.

In accord with one inventive concept, the network 10 actually utilizes two or more different types of protocol at levels above the protocol within the L2 layer that actually defines the network connectivity. The ADN network 10 may use different protocols at the higher layers as well. By distinguishing transmissions based on differences in these higher-level protocol types, the ATM switch 19 separately forwards different types of communication traffic for each subscriber. In the preferred embodiment, communications to and from the ISP or corporate networks 11 utilize point-to-point protocol (PPP) as the network layer (L3) protocol and a shim for transport of PPP over Ethernet (PPPoE). PPPoE, as one EtherType protocol could also be considered as a second layer (L2) protocol albeit above the Ethernet layer itself, which in turn rides on the ATM cells used for routing at least through the permanent virtual circuit at the L2 layer.

In the illustrated implementation, however, the use of the PPPoE or a different protocol actually is an indication of a difference in type of the higher layer protocols. In the illustrated example of FIG. 2, the vertical services domain traffic utilizes Ethernet (802.3 SNAP) above the ATM adaptation layer (AAL). As noted, the presently preferred L3/4 switch 19 implements its routing decision based on recognition of the EtherType indicator, that is to say to distinguish the PPPoE traffic from all other types of transmission from the customers' data equipment. In view of the use of ATM as the data link layer (L2) protocol of the network defining the lowest layer of network connectivity for communica-

23

tions services through the ADN network 10, the discrimination based on Ethernet actually implements a decision based on an effectively higher protocol layer.

IP protocol carries the actual higher-level applications information, for transport to and from the vertical services domain and for transport to and from the wide area internetwork. As such, IP and its related transport protocol referred to as the "Transmission Control Protocol" (TCP) ride on top of (are actually encapsulated within) the lower level protocol elements discussed above. Presentation and application layer elements ride on top of the IP layer. IP communication requires that each user device have an assigned IP address. IP addresses, however, are a scarce commodity. Because of the use of IP transport for both wide area services and vertical domain services, the network 10 actually may at times assign two different IP addresses to each active data communication device of an end-user, albeit on a temporary basis. The wide area communications and the vertical services network may also be viewed as two separate 'broadcast' domains.

First, the carrier operating the ADSL data network 10 and the vertical services domain network 13 will maintain a pool of local addresses for assignment, on an as-needed basis, to end user equipment 25. To the carrier, the available IP addresses are a limited resource. Accordingly, the carrier assigns IP addresses on a dynamic basis, only to those users actually on-line at any given time. The carrier preferably utilizes private network type IP addresses and dynamically administers such addresses using dynamic host configuration protocol (DHCP). DHCP is a protocol for automatic TCP/IP configuration, which enables dynamic address allocation and management.

When a particular device 25 becomes active via the ATU-R 23 and the DSLAM 17, it will activate a basic protocol stack, including an IP portion enabling communication with a DHCP server. The device will transmit an address request upstream through the network on the subscriber's virtual circuit. At the Ethernet level, this transmission appears as a broadcast message. The L3/4 ATM switch 19, however, will recognize that the packet is not a PPPoE communication and route the cells carrying the packet into the vertical services domain 13. Typically, a DHCP server is coupled to the vertical services domain network 13, for example as part of the carrier's administrative network or systems 33. The DHCP server somewhere on the vertical services domain 13, 33 will answer that broadcast request by selecting and providing an available one of the private IP addresses from the carrier's pool of available addresses. The message with the assigned address will go back to the L3/4 ATM switch 19 for insertion into the virtual circuit and transport back to the requesting device 25.

The particular end-user's device 25 uses the assigned private IP address as its source address, for all of its communications with the vertical services network 13, so long as it remains on-line for the present session. When the overall session ends and the end-user device 25 goes completely off-line, the DHCP server returns the private IP address to its pool of available addresses, for reassignment to another user as the next user comes on-line.

As noted, the user equipment 25 receives a private IP address from the DHCP server. The addresses of services on the vertical services domain also are private IP networks. Because these addresses are private, they are accessible only to equipment within that domain and the data network 10. Consequently, the devices are not accessible to hackers or the like coming in through the public Internet.

24

This dynamic assignment of IP addresses allows the carrier to limit the number of IP addresses used to the number of users actively connected through the ISP's host to the Internet. The use of private IP addresses allows the user equipment to communicate with the vertical services domain utilizing a normal IP-Ethernet protocol stack.

For the as-desired Internet access service, for example using a PPP or similar protocol, IP addresses are administered through the ISPs. The PPPoE protocol preserves or emulates the traditional dial-up approach to ISP access. However, the PPPoE approach does utilize Ethernet and follows Ethernet standards, for example, involving processing of certain broadcast messages.

The user can select an ISP of choice, and her data equipment 25 will initiate a selective session through the Ethernet layer on the network 10 to access the equipment 31 of the selected ISP network 11, in a manner directly analogous to a dial-up modem call through an ordinary telephone network. Hence at a time after initial activation through the networks 10 and 13, the user may activate a browser or other program for using the wide area internetwork service. This activates a second protocol stack, which includes the PPP protocol and the PPPoE shim. The user selects an ISP, and the data equipment initiates communication through the network 10 to the PPPoE equipment 31 of that ISP.

The IP addresses used by each ISP are public network type IP addresses. To the ISP, the pool of available public IP addresses also is a limited resource. Accordingly, each ISP prefers to assign IP addresses on a dynamic basis, only to those users actually on-line at any given time. Typically, as part of each initial access operation for a PPPoE session, the user's equipment 25 and the PPP terminating equipment 31 of the ISP conduct a handshake, to establish data communications therebetween. As part of this operation, the user's device transmits a broadcast request for a public IP network. The broadcast message, in PPPoE goes through the virtual circuit to the gateway router 29 and through the router and cell relay network 30 to the ISPs PPPoE equipment 31. Although it is a broadcast message, the network effectively limits transport thereof to the virtual circuit going to the ISPs PPPoE equipment 31, that is to a domain separate from the vertical services network domain 13.

The ISP host equipment 31 initiates a procedure to assign the user's computer 25 a numeric Internet Protocol (IP) address from the pool of available public addresses and sends a PPPoE message containing that address back to the subscriber's device 25. When the session ends and the user goes off-line, the ISP host can reassign the address to another user, as the next user comes on-line.

This dynamic assignment of IP addresses allows the ISP to limit the number of public IP addresses used to the number of users actively connected through the ISP's host to the Internet. The end-user equipment will implement a second protocol stack, carrying PPPoE communications. The PPP protocol will allow the end-user equipment to obtain and utilize the public IP address for communications going to and from the public internetwork.

The switch 19 will limit transport of other types of PPPoE broadcast messages to the link to the PPPoE concentrator 31, in a manner similar to that described above for the PPPoE address request. The switch 19 also limits transport of non-PPPoE broadcast messages to the vertical services domain network 131, both for the address request message and for other types of broadcast requests. As such, the logical circuit to the PPPoE concentrator 31 becomes the conduit to one broadcast domain for upstream PPPoE mes-

25

sages; and the vertical services network 13 defines a second broadcast domain for upstream messages of other Ether-types.

As noted, the end-user equipment 25 will implement two protocol stacks, a native stack without PPPoE and a second stack with PPPoE and a shim. In actual operation, both the native stack with other Ethernet protocols and the wide area stack with PPP and the PPPoE shim often will be active at the same time. The software in the data equipment 25 will utilize one stack or the other depending on whether the user selected a link, e.g. a URL, relating to the wide area internetwork or the vertical services domain. For example, a browser may display a page with embedded links. If a link is to a service on the vertical services domain, the embedded address will be a private address on the vertical services domain. Selection of such a link causes the device 25 to use the native Ethernet stack (without PPP or PPPoE) and the private address. Hence the L3/4 ATM switch 19 routes the request triggered by selection of the link to the vertical services domain 13. In contrast, if the link is to a service on the public Internet or other network 11, the embedded address will be a public IP address. Selection of such a link causes the end-user device 25 to use the PPP and PPPoE stack and the public address. Hence the L3/4 ATM switch 19 routes the request triggered by selection of the link over the virtual circuits to the PPPoE equipment 31 of the currently selected access provider network 11.

Services provided on the vertical services domain therefore appear as simple IP data services, albeit using the appropriate address space. Virtually any communication service provider may access the vertical services network 13 and through it the carrier's local customer base simply by providing an IP interface for coupling appropriate equipment to the vertical services network. For example, it is a simple matter to connect a direct satellite broadcast receiver system, similar to those used today in residential applications, through an IP interface to provide the full range of received video services over the vertical services network 13. This network may distribute the video programming to a number of L3/4 ATM switches 19, within a local geographic area serviced by the ADN network 10. The L3/4 ATM switch 19 co-located with the DSLAM 17 provides an optimum point for frame or cell replication for multicasting services.

For a multicast service, such as the satellite-originated video broadcast service, the service provider sends one stream through the vertical services domain network 13 to the L3/4 ATM switch 19. The switch 19 will monitor every ATM virtual circuit going to the subscribers, looking for IGP requests. A subscriber sends an IGP request to join a selected multicast channel. When the L3/4 ATM switch 19 detects such a request, it identifies the requested channel and the requesting subscriber equipment and forwards a 'join' message to the vertical services domain. Subsequently, the switch 19 replicates received packets for the requested broadcast channel, and the switch drops the replicated

26

packets into the cells for each of the virtual circuits of all of the joined subscribers, including the newly added subscriber. When the subscriber later elects to end viewing of the multicast, the subscriber's equipment sends a 'leave' message, and the switch 19 stops adding the cells for the multicast to that subscriber's virtual circuit.

In addition to vertical services, the carrier continues to provide agreed access services to the equipment of the ISPs, in a manner analogous to current practices. For example, the carrier may provide its Internet access service to a subscriber on a monthly subscription basis, at one of several available rates corresponding to the grade of internet access service (and thus the rate of communication to/from the ISP) selected by the customer's subscription.

In an enhanced service offering, the broadcast provider could offer a convenient navigation interface from a web server. The server could be on the vertical services network, but preferably is on the wide area Internet 11. With a PPPoE session active, the user can surf to the provider's server and view information about available programming. The user might select a current broadcast program by 'clicking' on a URL link in the provider's web-based information. Although provided through the wide area Internet 11, the URL would actually contain the private IP address for the desired broadcast program available from the vertical services network 13. Selection of such a URL therefore would generate a message to the appropriate server on the vertical services network 11 to initiate the above discussed procedure to allow the user to 'join' the selected broadcast. A similar methodology might also enable a provider to offer menu, selection and order/billing services from the Internet 11, to provide pay-per-view or video on-demand type services from the vertical services domain network 13.

Although IP-based, the services from the vertical services domain 13 may follow any other desirable business model. For example, a multicast service provider may contract with the carrier to provide multicast audio (radio-like) and/or video (TV-like) services via the vertical services domain.

The multicast service provider, not the subscribers, would pay the carrier. The multicast service provider may offer any or all of the multicast programming to customers on some type pay-per-view basis but would likely offer most of the programming service for free or bundled in as part of some nominal monthly subscription charge. The multicast service provider instead would charge advertisers in a manner analogous to current broadcast business practices. Advertising distributed with the IP multicasting, however, can be carefully targeted at end-customers having demographic profiles meeting specific criteria specified by individual advertisers, which allows the multicast service provider to charge premium advertising rates.

Table 2 summarizes the characteristics and requirements of a number of examples of the types of vertical services that the VSD network 13 can deliver via the L3/4 ATM switch 19 and the ADSL data network 10.

TABLE 2

Vertical Service Offering	Characteristics of the Service	Network Requirements
Voice Services	Local Co-Located VoIP Gateways, VoIP, Unified messaging, IP PBX, IP Centrex	Low latency, low jitter, non-correlated packet loss, and high availability
Video On Demand (Unicast)	Local VOD Servers or access to centralized servers.	High bandwidth, low jitter, high availability, and low packet loss

TABLE 2-continued

Vertical Service Offering	Characteristics of the Service	Network Requirements
Multimedia Broadcast (Multicast)	Supports whatever model of server deployment/content delivery mechanism.	
Caching Services	Broadcast Video; Broadcast Audio; Satellite Down Link support; Local Servers at the edge. Local servers at the insertion point, Local delivery mechanism for generic media objects such as web pages, images, video files, audio clips, software downloads, etc.	Varies with content type and with multicast implementation Layer 3 visibility
Distance Learning (EVC)	Integrated interactive video, voice and data	Low latency, low jitter, non-correlated packet loss, and high availability
Telecommuting	Closed user group with access to Transparent LAN Service (TLS).	IEEE 802.1Q

The above discussed preferred embodiments implemented the processing above the layer-2 protocol in an enhanced ATM switch and focused on implementation over an xDSL network specifically designed for use of twisted pair wiring to the customer premises. Those skilled in the art, however, will recognize that the principles of the present invention are equally applicable to other types of layer-1 and layer-2 transport/switching technologies as well as selection based on other protocols above the layer-2 connectivity protocol. FIG. 5, illustrates the implementation of the layer 3/4 and higher switch functionality in a generic access router (AR) 61. The illustration also teaches the provision of digital subscriber line data communication between the access router (AR) 61 and a number of customer premises, using a variety of line technologies. The digital line technologies include dial-up modems 63, 65 as well as wireless communications between wireless asymmetrical subscriber loop (WASL) transceivers 67, 69. The access router (AR) 61 can service residential customers via these other communication technologies as well as through the DSLAM 17 and the ATU-R 23 as in the earlier embodiment. The access router (AR) 61 also serves business customer router equipment 71, using a variety of fast frame/cell packet technologies 73-76 and even optical fiber (SONET) 71.

Those skilled in the art will recognize that even these examples are limited. For example, the invention may apply to pure video networks, such as in a hybrid fiber-coax implementation of a CATV system with digital video service as well as cable modem service.

The access router (AR) 61 will provide one or more types of logical circuits, implemented in the appropriate layer-2 protocol(s), e.g. ATM, frame relay, etc. Although the links to the wide area internetwork and the vertical services domain have been omitted here for simplicity of illustration, the access router (AR) 61 will provide the routing functions to and from the wide area internetwork and the vertical services domain in a manner similar to the functionality of the L3/4 ATM switch 19 in the earlier embodiment. In this regard, the access router (AR) 61 will support the QoS levels and will enable local insertion of vertical services.

FIG. 6 depicts a portion of the network of FIG. 5, showing the interconnection thereof with the wide area internetwork and the local vertical services domain. The vertical services network itself may include a number of routers (R) 73. Through that network, the access router (AR) 61 provides communications with services in the VSD that may be purely local, somewhat distributed or even centralized. True long distance data services, such as chat rooms, email and web browsing on the public Internet, however, are consid-

ered as Off-Net services, since they are accessed via the Internet access connection under the associated SLA.

Another feature of the present invention relates to a technique for customer-centric selection of telecommunications services and associated automated provisioning of the customer's data network services. The preferred embodiment of this feature of the invention utilizes a correlated information flow, in which the customer's MAC address has a corresponding, temporary IP address and a corresponding virtual circuit identifier (or VPI/VCI). A related aspect of invention encompasses software for implementing the automated provisioning of services through the access data network.

FIG. 7 is an enhanced block diagram of the access data network, showing certain additional elements involved in the automated selection and provisioning of customer services. FIG. 7 also is the first of several drawings showing an enhanced CPE device for use with the inventive ADN network. Elements of the network referenced by the same or similar numbers as shown in the earlier drawings are substantially the same as like numbered elements discussed above, for example relative to FIGS. 1 and 2.

The provisioning methodology enables a customer that is capable of receiving vertical services to use a web-based software application to order service. The automated interaction of the user through the common web-based software application causes communications to software entities extant in one or more of the services domains, which coordinate the processes that will automatically provision the corresponding data circuit, according to both customer-selected parameters and detected network parameters. This service selection and provisioning technique significantly reduces, or completely removes, the errors present in the previous data circuit provisioning processes, such as: manual ordering processes; manual record-keeping; and manual circuit changes at the PSTN frame and the intermediate ADSL frame.

The network of FIG. 7 is arranged and provides services essentially as described above, except that certain servers are operated on the Internet or preferably within a privately controlled area or domain of the vertical services networking to enable the customer-selection of telecommunications services and the associated automated provisioning of the customer's data network services. For example, the illustrated embodiment shows a DHCP server 81 within the network services domain 33 (carrier's private portion associated with the vertical services domain through the node 18). The carrier will also operate a web server 85 from the vertical services domain 13, although this server could

operate from the public Internet. The carrier also operates one or more provisioning servers 87, for example, via the network services domain 33. The physical network of the vertical services domain 13 and the network services domain 33 may overlap or be substantially the same. The network services domain, for example, may comprise a private virtual network set up for the carrier's own network-operations through the same network as forms the vertical services domain.

The user will run a standard Internet browser application 83, for example on a PC 25 or other appropriate data communication device. The web server 85 and the provisioning server 87 run one or more applications 91, 93 and 95 related to the service selection and provisioning operations, as discussed in more detail below.

Certain communications, discussed layer, may be exchanged between the servers, 81, 85 and 87, for example via the node 18 and physical links of the domains 33 and 13. The provisioning server 87 also communicates with the actual service transport elements of the access data network, such as the DSLAM 17, the switch 19, and the gateway router 29, to conduct a metering operation and/or to activate and control provisioning of services through such elements. The links between the provisioning server 87 and these elements, shown by dot-dash lines in the drawing, may go through secure logical channels through the network services domain 33 and the node 18 or may use other private data communication links.

The preferred embodiment allows the user to select services via a standard web browser interface, that is to say using a browser application 83. The browser application 83 communicates with a Service Application 91. The carrier also utilizes two software modules, a Metering Application 93 and a Provisioning Application 95 in the presently preferred embodiment. The Service Application 91 and the Metering Application 93 may run as one or more programs on the web server 85, the provisioning server 87 or some other server securely maintained by the carrier in one of the vertically inserted domains. For example, the Service Application 91 may run as one or more of the programs on the web server 85; whereas the Metering Application 93 and the Provisioning Application 95 preferably run on one or more provisioning servers 87 in the network services domain 33. Alternatively, the Metering Application 93 could run on one of the actual service transport elements of the access data network, such as the DSLAM 17 or the switch 19.

Also shown in FIG. 7 are a modified CPE/ATU-R 22, a browser application 82 running on the PC 26 connected to the CPE/ATU-R 22, and a CPE programming application 92. According to an embodiment more fully described later, the CPE/ATU-R 22 alters the data frames, if necessary, received from the PC 26 and other user devices at the premises before the data frames are forwarded to the DSLAM 17. The browser application 82 interfaces with an application 92 on the web server 85 to facilitate programming of the CPE/ATU-R 22.

The hardware of a server system, such as the server 85 or the server 87, corresponds to that of a typical general-purpose computer, comprising a central processing unit (CPU) formed for example of one or more microprocessors, a number of memory devices and an interface to the data communication network, in this case to the IP network forming the respective domain 13 or 33. Such a server computer may also provide a local or remote graphical user interface (GUI) for operation and control of the server by carrier personnel. Such an interface, for example, may

comprise a common type of display, a keyboard and one or more of the common types of cursor controls. Various media, readable by such a computer system, may store or carry the executable code and any associated data for the respective Application, for example the web pages provided by the server 85 and/or the associated code of the Service Application 91, for the Metering Application 93 or for the Provisioning Application 95. Examples of such media include semiconductor and disk type memories, digital tapes, and the like. Computer readable media used by such systems also include various types of signals sent and received by computer systems for loading software code, associated data and/or web pages into the memory and/or the CPU of the respective server system hardware.

FIG. 8 shows the actors, activities, and attendant messages involved in this exemplary method. Each activity resides in the domain of a particular actor: the customer domain 800, the carrier/PSTN domain 810, or the service domain 820.

With reference to FIGS. 7 and 8, the method begins when the customer contacts the carrier and requests ADSL service (step 801). The carrier connects the ADSL circuit (step 811), which entails moving the customer's POTS circuit to the ADSL frame at the remote terminal or central office, and cross-connecting back to the switch frame.

In step 802, after receiving and setting up the ADSL equipment and concomitant software, the customer starts an IP session over the ADSL line. In doing so, the customer's PC 25 (acting as a DHCP client) automatically requests and negotiates an IP address (step 8211) and other operational parameters with a DHCP server 81 in the network services domain 33. This IP address obtained in step 8211 is temporary, as it is used solely for the purpose of establishing a session. Later, the customer will receive a permanent or session IP address from its ISP/Global Service Provider (GSP) 11'.

In step 803, the customer uses the Web browser application 83 to access one or more of the network service provider's service pages via the PC 25, for example, from the web server 85 on the vertical services domain 13. In order to avail the customer of the services and GSPs 11' that will work acceptably well on the customer's particular ADSL line 21, the Service Application 91, determines the available services by acquiring a bandwidth metric (e.g. packet rate) from the Metering Application 93 (step 822). As shown in steps 823 and 804, the Metering Application 93 employs an interactive method for determining the maximum data rate. This rate determining method may be based on a damped oscillation algorithm, and may employ the mechanisms inherent to TCP. In the preferred embodiment, the Metering Application 93 should be in the core of the service domain 13 or 33 so as to measure the TCP/IP packet rate between the subscriber equipment and the respective services domain. However, other metering application techniques may be used from the same or other locations.

In step 824, the Service Application 91 sends a Web page to the customer, populated with the available services and identifications of the GSPs. In step 805, the customer selects services and one (1) primary GSP. Step 824 involves a determination of the customer's data rate, which will be the lower of the metered rate and a rate based on the customer-selected services.

In step 825, the Service Application 91 receives the customer's selections, and requests the data circuit by sending customer's IP address and data rate. In step 826, the Provisioning Application 95 obtains the customer's MAC address from the DHCP server 81.

In step 827, the Provisioning Application establishes communications with the vertical services insertion (VSI) ATM switch 19, and may use a script or other remote mechanism to either request the appropriate data circuit, or set up the data circuit (8121). The data circuit will have an association with the customer's MAC address, and will have a provisioned peak rate no less than that initially determined by the Service Application 91.

In step 828, the Provisioning Application 95 receives the logical circuit information (or VCI/VPI) for the customer, and subsequently communicates with the gateway router 29 to set up the appropriate logical circuit (or VPI/VCI) for the customer (step 8131). In step 813, the gateway router 29 may set up the circuit in response to a request from the Provisioning Application, or may be controlled by the Provisioning Application. The Provisioning Application 95 may similarly communicate with the switch 19 or the DSLAM 17, as appropriate, to provision the customer circuit. Thus, the customer has a PVC that traverses the exemplary ADSL data network, and this PVC was set up using the automated method presented here.

Certain aspects of the invention relate to the software elements, such as the combination of the Service Application 91, the Metering Application 93 and the Provisioning Application 95, shown in FIG. 7. Other aspects of the invention relate to software elements of the CPE device 22, as discussed more below. At different times all or portions of the executable code for any or all of these elements may reside in physical media or be carried by electromagnetic media. Physical media include the memory of the server(s) 85, 87, or the CPE device 22 such as various semiconductor memories, tape drives, disc drives and the like of general-purpose computer systems. All or portions of the software may at times be communicated through various networks, for example to load the software from another computer into the respective CPE device or server, or into another network element. Thus, another type of media that may bear the software includes optical, electrical and electromagnetic waves, such as used across physical interfaces between local devices, through wired and optical landline networks and over various air-links.

In the ADN depicted in FIG. 2, a customer's PC 25 was described that utilizes one or more protocol stacks to encapsulate IP datagrams, or other higher level data, in an Ethernet frame using an appropriate Ethernet type. In particular, the PC 25 included a protocol stack with a PPPoE shim that encapsulates and decapsulates data between a PPP layer and an Ethernet layer of the protocol stack. The resulting PPPoE Ethernet frames as well as other ethertype frames are exchanged between the PC 25 and an ATU-R 23 to communicate with the carrier's network.

With the different protocol stacks residing on the PC 25, customers could unintentionally disable PPPoE functions during routine configuring of the PC 25, performing operating system upgrades, or installing additional software applications. Also, in the embodiment of FIG. 2, each device is responsible for providing an appropriate PPPoE shim in order for that device to communicate, through the ADN, with remote Internet sites. While conventional PCs can easily include such functionality, other intelligent devices such as toasters, IP phones, climate systems and security systems do not necessarily include PPPoE shim functionality.

An alternative embodiment of the present invention is now described that addresses some of the concerns that can arise from placing the PPPoE shim functionality on the PC

25. In this alternative embodiment, depicted in FIG. 9, VSI customer premises equipment (CPE) 902 is coupled with the ATU-R 904 to provide some of the Ethernet encapsulating function previously performed by the PC 25. FIG. 9 illustrates the CPE 902 and the ATU-R 904 as a logical unit; these logical units, however, can be combined in various equivalent physical arrangements. For example, the ATU-R can include upgradeable firmware that can be augmented to permit the ATU-R 904, in addition to its conventional functions, to provide the functions of the CPE 902. The CPE 902 can be a stand-alone hardware piece located between the home network 906 and the ATU-R 904. The CPE 902 can also be a hardware apparatus that physically connects to interfaces on the ATU-R 904 or, depending on the modularity of the ATU-R 904, the CPE 902 could be a plug-in module that connects to a chassis or bus of the ATU-R 904.

In operation, devices 901₁-901₄, connected over a home LAN 906, communicate with the CPE 902 via conventional Ethernet, or other data-link layer, frames. While native Ethernet devices 901₁-901₄ are preferred, devices configured for other network types, such as HPNA, can be used along with a frame translator that bridges signals between Ethernet and the other network type. The Ethernet, or other data-link layer, frames received by the CPE 902 have IP, or other network-layer, datagrams, with a destination address and other higher layer information, encapsulated within. In response to receiving Ethernet, or other data-link layer, frames from the network 906, the CPE 902 generates Ethernet, or other data-link layer, frames that are then encapsulated in ATM cells according to the underlying Layer 2 architecture of the ADN and forwarded via the DSL link 908 to a VSI device 910. As described earlier, the VSI device routes the Ethernet, or other data-link layer, frames according to the type identifier (e.g., ethertype) within the frames to a vertical service domain locally connected to the VSI device 910 or to the Internet via a gateway router 912.

In generating, for example, Ethernet frames, the CPE 902 examines upper layer information within the frame received via the home LAN 906 and determines the appropriate ethertype encapsulation according to the service on the ADN to which that Ethernet frame is destined. The CPE 902 then generates an Ethernet frame according to the appropriate ethertype just determined. This generated Ethernet, or data-link layer, frame is forwarded over the ADN according to the underlying layer 2 architecture (also a data-link layer) of the ADN. In this manner, each device 901₁-901₄ need only include conventional Ethernet based protocol stacks, with the CPE 902 providing the shim software to alter data-link layer frames. Thus, the PPPoE shim software, in the Ethernet example, is protected from misconfiguration and damage caused by a customer's activities.

The table 920 illustrates one exemplary scheme for the CPE 902 to determine the appropriate ethertype encapsulation for a received frame. The table 920 depicts a modified version of a routing table which is typically found (in unmodified form) in devices with TCP/IP protocol stacks communicating over Ethernet networks. Each row of the table 920 is an entry for a particular destination IP network. The left-most column 922 identifies the network or domain to which a particular table entry applies. The middle column 924 identifies a subnet mask that is typically used to specify how many bits of an IP address to use when searching for a matching table entry. The right-most column 926 identifies the ethertype appropriate for a particular table entry (i.e., IP network). The first entry (network 0.0.0.0) is typically considered the default route; this means that if an explicitly matching entry is not found in the table 920 then this default

entry is used. As shown, the default ethertype is PPPoE which, according to one VSI embodiment described herein, denotes Ethernet frames ultimately destined for the Internet. The next two entries identify private IP networks, such as those used in the central office to provide inserted vertical services, local network services and/or VLAN services. As shown, Ethernet frames destined for the networks providing the various local or vertical services are encapsulated in an Ethertype other than PPPoE. The VSI device 910 is able to route the frames appropriately based on the frames' ethertypes.

The table 920 is exemplary in nature and is not intended to limit the scope of what upper layer information can be used to determine the appropriate encapsulation ethertype. Information from the transport layer, or even the application layer, could be used by the CPE 902 for ethertype determinations.

FIG. 10 illustrates a schematic hardware view of a CPE/ATU-R device 1000 according to an embodiment of the present invention. The circuitry for performing the conventional functions of an ATU-R or a router are not illustrated in the apparatus of FIG. 10 as these functions are not critical to an understanding of the innovative aspects of the CPE 1000. For example, the SAR circuitry for exchanging ATM cells to and from the upstream side of the ATU-R is not shown. Similarly, the circuitry for examining a downstream packet to determine which Ethernet port interface to forward the packet to is not shown in detail.

LAN interface ports 1002₁-1002₄ communicate with devices on a home (i.e., customer location) network preferably using conventional Ethernet frames that encapsulate higher layer data. Ethernet frames received via the interfaces 1002₁-1002₄ are forwarded to the router, or multiplexer, circuitry 1004. A processor 1010, or other equivalent circuitry, then examines the higher layer data encapsulated within the Ethernet frame to determine an intended network destination. From the intended destination, a matching table entry, from a table 1014 stored in the memory 1012, is identified. Based on the identified table entry, the Ethernet frame is encapsulated according to one of a variety of ethertypes. The encapsulation according to the different ethertypes performed by the CPE device 1000 can range from being as complex as restructuring the entire frame and its header to as simple as altering, or setting, a multi-bit "type indicator" field within the frame's header. The appropriately encapsulated Ethernet frame is then forwarded out the ATU-R 1008. Buffer 1006 is shown as a part of the router circuitry 1004 in consideration that encapsulation and unencapsulation of Ethernet frames takes a finite period of time in which other frames can be received. As well understood in network switches, the buffer 1006 prevents the loss of data during the processing of incoming and outgoing Ethernet frames.

With respect to downstream traffic, the CPE 1000 can detect the ethertype of a received frame without reference to a routing table and therefore can automatically translate between the incoming ethertype and the conventional ethertype used by the home LAN. However, the router 1004 does function to determine the appropriate interface 1002₁-1002₄ to forward a frame to based on which interface 1002₁-1002₄ the downstream destination device is connected to. Accordingly, the CPE device 1000 can perform session proxy functions such as network address translations and other routing procedures.

FIG. 11 depicts a more logic-level view of the CPE/ATU-R device described in relation to FIG. 10. The different

ethertypes can be thought of as logical ports. Analogous to a typical network switch, an incoming frame is analyzed by the CPU that implements a switching function to determine the appropriate outgoing interface. Instead of multiple physical output interface ports being the possible destinations, logical ports 1102, 1104 and 1106 are the possible output destinations to select from. Each of these logical ports represents different level 2 encapsulation software of a protocol stack, or stacks. In operation, the CPU 1110 analyzes upper layer information within a received Ethernet frame to determine which logical port 1102-1106 to forward the frame to. The CPU 1110 consults data 1112 in a memory 1114 in determining the appropriate logical port. As a result of being forwarded to the different logical ports, different Ethernet frames are encapsulated as different ethertypes. Within the VSI environment, therefore, the different frames can be routed to either vertical services or conventional Internet-based services domains based on their ethertypes.

In addition to the benefits previously mentioned, the placement of the PPPoE shim functionality out on the CPE device provides a number of other advantages.

Security of the home network can be enhanced utilizing the CPE with the PPPoE shim functionality. Most routers have firewalling capabilities that are typically implemented via an access control list (ACL) mechanism. The table 930 illustrates an exemplary security table that has entries corresponding to MAC addresses of the devices 901₁-901₄ on the home network 906. Each entry includes a MAC address and a corresponding rule. While the precise syntax of the rules differs among different vendors, the rules typically specify what destination and origination equipment can communicate with a particular MAC address. According to one aspect of the present invention, the ACL rules can be extended to identify what types of ethertype encapsulation are allowed for the different devices 901₁-901₄ of the LAN 906. For example, a PC will likely communicate with the vertical services domain as well as the Internet, but a home security system probably will only communicate with the vertical services domain. Accordingly, a security table entry can be created to prevent PPPoE (i.e., Internet) sessions from being started by, or received by, the security system. When processing frames, the CPE will check not only the routing table to determine the appropriate ethertype encapsulation but will also refer to the ACL to determine whether or not to process the frame at all.

In addition, having a protocol stack with a PPPoE shim located at the CPE 902, allows the CPE 902 to function as a PPPoE proxy, if desired. In a proxy arrangement, the CPE initiates a PPPoE connection to an ISP similar to the manner described earlier in conjunction with a customer's PC establishing a PPPoE link. Thus, the CPE 902 is allocated a public IP address. The different devices 901₁-901₄ communicate with the CPE 902 via standard Ethernet frames which the CPE 902 encapsulates and multiplexes over the PPPoE connection (assuming the frames are destined for the Internet). Return PPPoE frames are addressed to the CPE 902 which, using conventional network address translation (NAT) methodology, demultiplexes the received return frames to the appropriate devices 901₁-901₄. This proxy functionality provides the ability to share a single PPPoE link among multiple home devices 901₁-901₄ and improves security by preventing direct communication with the devices 901₁-901₄. Of course, the PPPoE proxy arrangement is optional. Devices 901₁-901₄ can also independently establish their own PPPoE links so that each of them has a separate IP address and PPPoE session.

One of the significant benefits of the CPE and ATU-R equipment depicted in FIG. 9 is that upstream quality of service (QoS) can be provided. Implementing downstream QoS has been described in detail with regard to the VSI switch. A similar methodology can be utilized with regards to the upstream data. The CPE can determine the physical upstream rate of different traffic types and then prioritize and queue traffic according to predetermined traffic types. As described with regard to the VSI switch (FIG. 2, element 19), the CPE can examine each communication and determine an appropriate tag to add to an outgoing cell as part of its internal processing. Using the tags, the CPE will place each of the cells into one of a plurality of queues similar to those discussed above relative to QoS operations of the VSI switch. Thus, the order and rate at which different ethertype frames are forwarded out the ATU-R can be controlled to support QoS for various services between the customer and the carrier.

Generation and downloading of the programming information for the CPE/ATU-R 1100 can be accomplished manually via one of the customer devices connected to an Ethernet port 1002₁-1002₄. An embedded web server or similar application could be provided in the memory 1114 that communicates with the connected customer device to allow a customer to manually generate programming information such as the routing tables, ACL tables and QoS parameters. The CPE/ATU-R 1100 could also be similarly programmed via devices connected to it through the ATU-R interface 1008. In an embodiment described more fully later, the programming information is automatically generated and downloaded to the CPE/ATU-R 1100 via software extant in the local access network domain.

FIG. 12 provides a flowchart that summarizes the steps taken by the CPE in forwarding Ethernet frames to the ADN. In step 1202, an Ethernet frame is received at one of the interface ports. The Ethernet frame encapsulates datagrams. Information related to an upper-layer protocol is extracted, in step 1204, from the received frame. Examples of such information include the destination IP address encapsulated within the Ethernet frame. A set of rules (e.g., a routing table) is consulted to determine, in step 1206, what ethertype encapsulation needs to be used based on the extracted upper-layer information. Once the ethertype encapsulation method is identified, the datagram is re-encapsulated, in step 1208, using the identified ethertype encapsulation method. Once encapsulated, the frame, in step 1210, is forwarded upstream over the ADN. In performing the forwarding step (step 1210) the CPE can also consult security access control lists to identify permissible connections and sessions and block Ethernet frames when appropriate. Similarly, the CPE can also perform the forwarding step in a manner to ensure conformance with any QoS parameters associated with the upstream bandwidth.

Trained network personnel perform the complex configuration of the parameters that control the QoS functions for the downstream data of the ADN; a typical customer, however, does not have the knowledge to properly configure upstream QoS parameters. In a related point, many customer's would find it extremely difficult, if not impossible, to correctly generate ACLs, NAT information, and routing tables. One further aspect, therefore, of the architecture depicted in FIG. 9 is the capability for automatically programming the CPE based on the services a customer orders. In a preferred embodiment, the automatic programming of the CPE relies on some of the automatic provisioning software and services depicted and described in relation to FIG. 7.

The methodology relating to automatic programming of the CPE enables a customer to use a web-based software application to program the CPE. The automated interaction of a user through a web-based software application causes communications to software entities extant in one or more service domains, which coordinate the processes that will automatically configure the CPE according to both customer selected parameters and other network parameters.

Referring to FIG. 7, the user will run a standard Internet browser application 82, for example on a PC 26 or other appropriate data communication device. The web server 85 and the provisioning server 87 run one or more applications related to services selection 91 and CPE programming operations 92. Through the web interface, the user will select services that are appropriate for the devices 26 connected to the CPE/ATU-R 21. Through communication between the provisioning server 87 and other elements of the ADN, the provisioning server 87 and web server 85 will identify ethertype and corresponding network address information useful in populating a routing table such as that depicted in Table 920.

Based on the suite of services selected by a user, the provisioning server 87 and web-server 85, through coordinated processes 91, 92, 93 and 95, can also determine optimal queuing and prioritizing parameters to enable implementation of upstream QoS. The optimal queuing can be partly based on the experience and knowledge of network personnel; thus relieving the user from attempting such a difficult task.

Access to a web-based application 92 can be provided through the web-server 85 that will guide a user through the process of identifying network devices and services and in defining related security parameters, such as table 930. Preferably, this application communicates with other software elements, already described, regarding the services offered to and selected by the user so that the user is intelligently presented relevant options and alternatives while creating a security profile for use in the CPE 22. In FIG. 7, the web server 85 is depicted as running both the CPE Programming Application 92 and the Service Application 91; one skilled in the art would recognize that these two application can also be run on separate servers.

Ultimately, the security profile, the QoS parameters and the ethertype routing table will be downloaded via the ADN to the CPE 22 in order to automatically program the device. In one embodiment, a default configuration or a simple web-based interface is provided with the CPE 22 to perform the initial communications needed to initiate the communication session needed to perform a full programming of the device.

FIG. 13 depicts the logical flow of the software processes extant in the ADN that provide automatic programming of the CPE. A user, preferably via a web browser, connects (step 1302) to a web-server front end that coordinates the gathering of data needed to program the CPE. From web pages served (step 1304) by the front-end, the user can direct the gathering of relevant information. In particular, information relating to the services used by the customer, the devices present at the customer's location and the security preferences of the user must all be gathered (steps 1306, 1308 and 1310). The information does not necessarily have to be manually entered by the customer. Through other communication paths in the ADN the web server can identify those services subscribed to by a customer as well the upstream network bandwidth requirements of those services. Similarly, the CPE and the customer device's are connected

via the home network. Using such a connection MAC addresses and information regarding the devices can be gathered by the CPE and automatically passed to the web server front-end. Using the gathered information, a graphical, or other intuitive interface, can be presented to the customer to aid with the selection of meaningful and appropriate security Access Control Lists (ACL). Once all the information is gathered, the web server can generate, or access a back-end application that can generate, data formatted in a manner that can automatically program the CPE. Exemplary data that can be generated are the rule-sets that permit prioritizing and queuing to meet QoS constraints (step 1312), routing tables that associate a particular encapsulation method with network destination information extracted from a received frame (step 1314), and security tables that specify permissible communication target addresses, source addresses and session encapsulation types (step 1316). Once appropriately formatted data is generated, this data can be forwarded through the ADN of this particular user (step 1318). Upon receipt of the programming data at the CPE, the behavioral characteristics and parameters of the CPE are modified according to the downloaded programming (step 1320).

While the foregoing has described what are considered to be the best mode and/or other preferred embodiments of the invention, it is understood that various modifications may be made therein and that the invention may be implemented in various forms and embodiments, and that it may be applied in numerous applications, only some of which have been described herein. It is intended by the following claims to claim any and all modifications and variations that fall within the true scope of the inventive concepts.

What is claimed is:

1. A Customer Premises Equipment located between an access data network, providing access services to at least two network domains, and one or more customer devices that utilize services provided over the access data network, comprising:

- a first interface for receiving a first frame from the one or more customer devices;
- a second interface for forwarding a second frame upstream to the access data network, said second frame encapsulated according to a selected one of a plurality of encapsulation methods;
- a decision table for storing a correlation between each of a plurality of upper-layer network data and a respective encapsulation method;
- a circuit configured to:
 - extract upper-layer network data from the first frame;
 - identify a table entry corresponding to the extracted upper-layer network data; and
 - determine the selected one encapsulation method associated with the identified table entry; and
- a protocol stack for encapsulating data within the first frame into the second frame according to the selected one encapsulation.

2. The Customer Premises Equipment according to claim 1, wherein the circuit comprises a switch and the first interface includes a plurality of interface ports coupled to the switch for communicating with the one or more customer devices.

3. The Customer Premises Equipment according to claim 1, wherein the circuit comprises a router and the first interface includes a plurality of interface ports coupled to the router for communicating with the one or more customer devices.

4. The Customer Premises Equipment according to claim 1, wherein the protocol stack is configured to generate said second frame by modifying a type-identifier field within a header of said first frame if necessary to conform to the selected one encapsulation method.

5. The Customer Premises Equipment according to claim 4, wherein the type identifier field identifies one of a plurality of different ethertypes.

6. The Customer Premises Equipment according to claim 1, further comprising:

- a DSL modem coupled between the second interface and the access data network.

7. A Customer Premises Equipment located between an access data network, providing access services to at least two network domains, and one or more customer devices that utilize service provided over the access data network, comprising:

- a first interface for receiving a first frame from the one or more customer devices, said first frame comprising a payload and a first header;
- a second interface for forwarding a second frame upstream to the access data network, said second frame comprising the payload and a second header;
- a decision table for specifying a correlation between each of a plurality of types of upper-layer network data and a respective frame-type identifier;
- a circuit configured to:
 - extract upper-layer network data from the first frame;
 - identify a decision table entry corresponding to the extracted network data; and
 - determine a selected one frame-type associated with the identified table entry; and

a protocol stack for generating the second header by modifying the first header, if necessary, according to the selected one frame-type.

8. A method for providing upstream data frames from a Customer Premises Equipment, comprising the steps of:

the Customer Premises Equipment receiving, from a customer device that utilizes services over an access data network that provides access services to at least two network domains, a first data-link layer frame containing encapsulated data;

using the Customer Premises Equipment to:

- extract network services information from the encapsulated data, said network services information originating in a protocol layer higher than the data-link layer;
- identify a selected one of a plurality of data-link layer encapsulation methods based on the extracted network services information;

modify the encapsulated data by encapsulating it into a second data-link layer frame according to the selected one data-link layer encapsulation method; and

forward the second data-link layer frame upstream via the access data network;

wherein the Customer Premises Equipment is located between the access data network and the customer device, and the forwarding step comprises assigning a priority to the second data-link layer frame based on a network service associated with the data encapsulated into the second data-link layer frame.

9. The method according to claim 8, wherein the step of modifying consists essentially of modifying a value of a type-identifier in a header of said first data-link layer frame.

10. The method according to claim 9, wherein the type-identifier specifies one of a plurality of ethertypes.

11. The method according to claim 8, further comprising the step of:
queueing the second data frame in one of a plurality of queues based on the assigned priority.
12. The method according to claim 8, wherein the step of forwarding the second data frame is performed according to QoS guidelines associated with the data encapsulated into the second data-link layer frame.
13. The method according to claim 8, wherein the extracted network services information comprises a layer 3 destination network address.
14. The method according to claim 8, further comprising the steps of:
receiving a downstream third data-link layer frame from the access data network containing encapsulated data;
encapsulating the encapsulated data of the third data-link layer frame into a fourth data-link layer frame according to an encapsulation method compatible with the customer device; and
forwarding the fourth data-link layer frame downstream to the customer device.
15. The method according to claim 8, further comprising the steps of:
receiving a downstream third data-link layer frame from the access data network containing encapsulated data;
identifying one of a plurality of customer devices for receiving the encapsulated data of the third data-link layer frame;
forwarding the encapsulated data of the third data-link layer frame to the identified one customer device.
16. The method according to claim 8, further comprising the steps of:
determining if the customer device has authority to participate in a communication session with a destination associated with the data encapsulated within the first data-link layer frame; and
performing the modifying step and the forwarding step only if the customer device is determined to have the authority to participate in a communication session with the destination.
17. The method according to claim 16, wherein the step of determining if the customer device has authority includes the steps of:
identifying a MAC address associated with the customer device;
identifying authorized encapsulation methods associated with the identified MAC address; and
granting authorization if the authorized encapsulation methods include the selected one encapsulation method.
18. A computer readable medium bearing instructions for providing upstream data frames from a Customer Premises Equipment, said instructions being arranged to cause one or more processors of the Customer Premises Equipment upon execution thereof to perform the steps of:
the Customer Premises Equipment receiving, from a customer device that utilizes services over an access data network that provides access services to at least two network domains, a first data-link layer frame containing encapsulated data;
using the Customer Premises Equipment to:
extract network services information from the encapsulated data, said network services information originating in a protocol layer higher than the data-link layer;

- identify a selected one of a plurality of data-link layer encapsulation methods based on the extracted network services information;
modify the encapsulated data by encapsulating it into a second data-link layer frame according to the selected one data-link layer encapsulation method; and
forward the second data-link layer frame upstream via the access data network;
wherein the Customer Premises Equipment is located between the access data network and the customer device, and the forwarding step comprises assigning a priority to the second data-link layer frame based on a network service associated with the data encapsulated into the second data-link layer frame.
19. The computer readable medium according to claim 18, wherein the step of modifying consists essentially of modifying a value of a type-identifier in a header of said first data-link layer frame.
20. The computer readable medium according to claim 19, wherein the type-identifier specifies one of a plurality of ethertypes.
21. The computer readable medium according to claim 18, wherein said instructions being further arranged to cause the one or more processors of the Customer Premises Equipment upon execution thereof to perform the additional steps of:
queueing the second data-link layer frame in one of a plurality of queues based on the assigned priority.
22. The computer readable medium according to claim 18, wherein the step of forwarding the second data-link layer frame is performed according to QoS guidelines associated with the data encapsulated into the second data-link layer frame.
23. A method for providing upstream data frames from a Customer Premises Equipment, comprising the steps of:
the Customer Premises Equipment receiving from a customer device that utilizes services over an access data network that provides access services to at least two network domains, a first Ethernet frame containing an IP datagram;
using the Customer Premises Equipment to:
extract an IP destination address from the IP datagram;
forward, if the extracted IP destination address corresponds to an address in a vertical services domain, the IP datagram to the access data network in an Ethernet frame identified by a first ethertype; and
forward, if the extracted IP destination address corresponds to an address in an Internet domain, the IP datagram to the access data network in an Ethernet frame identified by a second ethertype, different from the first ethertype;
wherein the Customer Premises Equipment is located between the access data network and the customer device and the forwarding steps comprise assigning a priority to the Ethernet frame identified by the first ethertype or the second ethertype based on a network service associated with data in the Ethernet frame identified by the first ethertype or the second ethertype.
24. The method according to claim 23, further comprising the step of:
verifying that an entry in a security table authorizes forwarding the IP datagram to the access data network.
25. The method according to claim 23, wherein the second ethertype is point-to-point protocol over Ethernet.

US 6,798,751 B1

41

26. The method according to claim 25, further comprising the step of:
establishing a single PPPoE session between the Customer Premises Equipment and a service provider in the Internet domain.

42

27. The method according to claim 26, wherein any Ethernet frames forwarded to the access data network are forwarded upstream over the single PPPoE session.

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